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COMBAT VEHICLE COMMAND & CONTROL (93) RESEARCH REPORT (DRAFT FINAL)

The Combat Vehicle Command And Control System: Combat Performance Of Armor Battalions Using Distributed Interactive Simulation

Submitted By:
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December 15, 1993

Dr. Kathleen A. Quinkert
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Fort Knox, KY 40121-5620

SUBJECT: Transmittal of Draft Final CVCC Battalion Evaluation Operational Effectiveness Research Report

Dear Dr. Quinkert:

BDM Federal is pleased to deliver the draft final technical report entitled "The Combat Vehicle Command and Control System: Combat Performance of Armor Battalions Using Distributed Interactive Simulation." This report is the result of work performed under Combat Vehicle Command and Control Delivery Order 0003 (Advanced Distributed Simulation Technology, Contract No. N61339-91-D-0001/0025).

All comments from the 5 October 1993 ARI in-house review of the draft report have been incorporated, with the following exceptions:

a. Reviewer's RECOMMENDATION--page 4, comment 6a: This section understates the observed advantages of CVCC. For example, the number of calls for fire doubles, triples, and even quadruples in a stage where CVCC is available. If artillery missions were available, we should see a corresponding increase in some amount in the volume of artillery fires delivered and in the kills achieved by artillery.

RESPONSE: The narrative has been modified as far as possible given the current set of measures. Unfortunately, it is neither possible to reliably quantify the volume of of calls for fire using current data, nor is it possible to establish the number of missions fired, and any kills attributed to those missions. Furthermore, given the differences in methods of employment and effects between SIMNET and real-world artillery, any focus on artillery effect in SIMNET would probably be inappropriate.

b. Additional measures and analyses prompted from ARI's in house-review of the operational effectiveness technical report and the follow-up conference have been integrated in the research report, as well.

Please direct questions concerning this report to myself or Mr. Glen Meade.

BDM FEDERAL, INC.

Bruce C. Leibrecht, Ph.D.
Manager, Human Factors and
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Enclosures: as stated

CF: Dr. Doherty
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DRAFT
Research Report XXX

The Combat Vehicle Command and Control System: Combat Performance of Armor Battalions Using Distributed Interactive Simulation

Glen A. Meade, Ryszard Lozicki, Bruce C. Leibrecht, Paul G. Smith, and William E. Myers

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13. ABSTRACT (*Maximum 200 words*)

This research evaluated the operational effectiveness, training, and soldier-machine interface (SMI) implications of a Combat Vehicle Command and Control (CVCC) experimental configuration that included the Commander's Independent Thermal Viewer and a Command and Control display. Using M1 tank simulators in the Mounted Warfare Test Bed at Fort Knox, KY, the evaluation focused on tank battalion operations. Each of twelve groups of soldiers completed a 1-week training and testing schedule that culminated in a simulated combat scenario. One of a series, this report documents tactical unit performance, and techniques and procedures employed to take advantage of the CVCC system's capabilities. Companion reports address operational effectiveness data, and training and SMI-related findings. The collective findings provide input to the design and development of training programs for future automated command, control, and communications systems in ground combat vehicles.

14. SUBJECT TERMS

CVCC	Command and control	C3 training requirements
CITV	Operational effectiveness	Soldier-in-the-loop
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Research Report XXX

THE COMBAT VEHICLE COMMAND & CONTROL SYSTEM:

COMBAT PERFORMANCE OF ARMOR BATTALIONS

USING DISTRIBUTED INTERACTIVE SIMULATION

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FOREWORD

The Fort Knox Field Unit of the U.S. Army Research Institute for the Behavioral and Social Sciences (ARI) conducts soldier-in-the-loop simulation-based research that addresses Training Requirements for the Future Integrated Battlefield. Efforts under this program are supported by Memoranda of Understanding (MOU) with (a) the U.S. Army Armor Center and Fort Knox, Subject: Research in Future Battlefield Conditions, 12 April 1989, and (b) the U.S. Army Tank-Automotive Command (TACOM), Subject: Combat Vehicle Command and Control (CVCC) Program, 22 March 1989.

The CVCC research program combines advanced digital and thermal technologies to enhance mounted warfighting capabilities to accomplish command, control, and communications (C^3). The CVCC system includes digital map, report and overlay features, positioning and navigation functions, digital transmission capabilities, and independent thermal viewing for unit and vehicle commanders. This configuration provides a powerful medium for investigating combat development and training requirements of future automated technology for armored vehicles. The research reported here used Distributed Interactive Simulation to evaluate the CVCC capabilities at the battalion level. The preliminary findings presented in this report support Army developers in determining user requirements, specifying training requirements, and assessing operational effectiveness of automated C^3 systems for ground combat vehicles. In addition, the training and simulation techniques developed for this effort are of use to other Army training and testing agencies.

Information resulting from this research has been briefed to the following personnel: Commanding General, U.S. Army Training and Doctrine Command; Commanding General, U.S. Army Armor Center and School; Deputy Commanding General for Combat Developments, U.S. Army Combined Arms Command; Deputy Chief of Staff for Training, U.S. Army Training and Doctrine Command; Chief of Staff, U.S. Army Armor School; Director, Directorate of Combat Developments, U.S. Army Armor School; and Director, Mounted Warfighting Battlespace Lab.

EDGAR M. JOHNSON
Director

ACKNOWLEDGEMENTS

The following members of ARI's Fort Knox Field Unit provided invaluable input to this evaluation: Dr. Barbara Black, Field Unit Chief; Dr. Kathleen Quinkert, Leader of the Future Battlefield Conditions (FBC) Team; Dr. Carl Lickteig and Mr. Gary Elliott, FBC Team members; and MAJ Jimmy Whitehead, the Field Unit's Research and Development Coordinator.

In addition to the authors, The BDM Federal, Inc. research staff included Dr. William Doherty, Dr. Nancy Atwood, MG (Ret) Charles Heiden, Ms. Alicia Sawyer, and Mr. Owen Pitney. Dr. Laura Ford, Dr. Beverly Winsch, Mr. Jeffery Schmidt, Mr. Timothy Voss, Mr. Robert Sever, and Mr. Jack Burkett provided invaluable assistance in developing and editing the report. Research Assistants supporting the project included Mr. Silver Campbell, Ms. Ann Cash, Mr. Kenneth Fergus, Mr. Brian Gary, Mr. Lewis Graff, Mr. Gary Gulbranson, Mr. Michael Gustafson, Mr. John Jawor, Mr. David Johnson, Mr. Ronald Jones, Ms. Khristina Orbock, Mr. Robert Pollock, Mr. Ronald Reyna, Mr. Charles Sawyer, Mr. Daniel Schultz, Ms. Margaret Shay, Mr. Harold Wager, and Mr. Charles West.

Personnel of the on-site support contractor, Loral Training and Technical Services, supported simulation equipment and data collection/analysis. These included Mr. Jimmy Adams, Mr. Fred Brady, Mr. David Clippinger, Mr. Michael Krages, Mr. Paul Monday, Mr. Rob Smith, and Ms. Diane York.

THE COMBAT VEHICLE COMMAND & CONTROL SYSTEM: COMBAT PERFORMANCE OF ARMOR BATTALIONS USING DISTRIBUTED INTERACTIVE SIMULATION

EXECUTIVE SUMMARY

Requirement:

Meeting the command, control, and communications (C^3) challenges of the high speed, high intensity, widely dispersed future battlefield requires a knowledge of the use and capabilities of current and future automated C^3 systems. Systematic research and development efforts, including careful assessment of operational implications and training requirements, are necessary to field and deploy these systems. The U.S. Army's Combat Vehicle Command and Control (CVCC) research and development program uses soldier-in-the-loop, simulation-based methodology to evaluate future C^3 technology. Previous CVCC research focused on tank crews, platoons, companies, and the battalion Tactical Operations Center (TOC). A focus on performance of unit commanders and executive officers led to the battalion-level evaluation.

Procedure:

The research compared battalion operations in two conditions: (a) Baseline, modeling conventional M1 tank and TOC C^3 tools (mainly voice radio and paper maps), and (b) CVCC, supplementing Baseline capabilities with a digital Position/Navigation (POSNAV) system, a digital Command and Control Display (CCD), the Commander's Independent Thermal Viewer (CITV), and digital TOC workstations. Using autoloading tank simulators in the Mounted Warfare Test Bed (MWTB) at Fort Knox, Kentucky, eight MOS-qualified armor crews (battalion commander, battalion operations officer, three company commanders, and three company executive officers) were integrated with semiautomated elements under their control to form a complete tank battalion. Each battalion-group operated in either the Baseline or the CVCC condition, with six groups assigned to each. Each of the twelve battalions completed four days of training and testing, culminating in a simulated combat test scenario.

Findings:

The digital communications capabilities of the CVCC system resulted in significant improvements in both the accuracy and the amount of tactical information transmitted (e.g., FRAGOs, enemy and friendly information), while significantly reducing the amount of voice radio traffic. The POSNAV system allowed commanders and staff to maintain a more accurate and up-to-date appreciation of the unit's status, and to coordinate maneuver more effectively. The CITV enabled crews to acquire targets sooner and at a greater range than in the Baseline condition, and

to identify opposing force vehicles more accurately. CVCC units also achieved better target effects against OPFOR vehicles as demonstrated by a greater number of kills per hit--an effect tentatively related to improved identification. Overall, CVCC battalions demonstrated greater agility, depth, and synchronization in the conduct of tactical operations, and protected their force more effectively than Baseline units.

Utilization of Findings:

The results of this research provide insights to the operational effectiveness of tactical units using future automated C^3 systems in ground combat vehicles. The findings will be of use to combat and materiel developers, as well as modelers, other researchers, and unit commanders as wider applications of tactical digital communications are demonstrated and evaluated at the individual vehicle through brigade level.

THE COMBAT VEHICLE COMMAND & CONTROL SYSTEM: COMBAT PERFORMANCE OF ARMOR BATTALIONS USING DISTRIBUTED INTERACTIVE SIMULATION

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THE COMBAT VEHICLE COMMAND & CONTROL SYSTEM: COMBAT PERFORMANCE OF ARMOR BATTALIONS USING DISTRIBUTED INTERACTIVE SIMULATION

Introduction

Modern technology has led to significant developments in weapons design since World War II. Tanks, infantry carriers, and self-propelled weapons are more accurate, lethal, agile, and survivable than their predecessors. New intelligence gathering systems provide a wealth of raw information to the battlefield commander. Yet, despite significant developments in fire control systems, automotive design, armor protection, and target detection and acquisition, tactical communications and associated command and control (C^2) techniques have not changed much in the last fifty years. Throughout the battlefield, tactical commanders still rely on line-of-sight voice radio transmissions, augmented by what they can personally observe to control their forces. As a result, modern combat systems--both friendly and enemy--can easily outpace traditional decision cycles.

The Army's current keystone operations doctrine (Department of the Army, 1993a) portrays a contemporary and future combat environment characterized by speed, intensity, dispersion, and fluidity. Commanders and their staffs must rapidly analyze and act on available information to identify and mass fires at a decisive point in time and space. Highly mobile operations both enable and complicate the process, as commanders strive to synchronize various units, and maintain both security and surprise. Imperatives of force sustainment also present unique challenges as units must be resupplied and refitted. Finally, units that approach a known enemy position from different directions and at various ranges must be able to rapidly distinguish between enemy and friendly elements in order to direct fires effectively against proper targets. The lessons learned from Desert Storm (Department of Defense, 1992) graphically illustrate many of the command, control and communications (C^3) problems of a rapid maneuver battle, such as navigation difficulties, delays and interruptions to information flow, confusion about friendly and enemy locations, and instances of fratricide.

Digital technology offers the potential to pass large volumes of data in burst transmissions. This information can be translated in graphic and/or textual formats. Furthermore, certain types of data can be fully automated, and thus reduce manual reporting requirements. These capabilities can potentially enable the future leader to keep pace with the command and control challenges on the future battlefield. A comprehensive research and development effort is required to field and deploy combat-effective digital systems. The Army's C^3 modernization thrust aims to capitalize on an extensive network of digital nodes that will rapidly and reliably exchange combat-critical information. Under this thrust, the U.S. Army Tank-

Automotive Command (TACOM) sponsored a U.S.-German bilateral research and development effort. Known as the Combat Vehicle Command and Control (CVCC) program, this effort addressed automated C^3 requirements for ground combat vehicles. The program is managed by four teams, each with a German counterpart team: the Data Elements, Operational, and Organizational Concepts Team, chaired by the Directorate of Combat Developments, U.S. Army Armor School; the Communications Team, chaired by the U.S. Army Communications-Electronics Command; the Vehicle Integration Team, chaired by TACOM; and the Soldier-Machine-Interface and Simulation Team, chaired by the U.S. Army Research Institute for the Behavioral and Social Sciences (ARI). The efforts of the four teams are interdependent and mutually supportive.

As with any new technology, the potential of the CVCC system can only be fully realized through practical exploration. Although digital communications offer many possible applications, the concepts themselves must be refined through user tests. Furthermore, the new capabilities must be deployed with effective tactics, techniques and procedures (TTPs). The current effort is therefore concerned with identifying ways that the CVCC system might best benefit the battlefield commander, and potential modifications to mounted warfare TTPs. Another area of interest is the implication for digital integration among and between different elements of the combined arms team.

Prior CVCC evaluations have investigated the system's utility at company level and below, as outlined later in this work. This report, one of three from the CVCC battalion-level evaluation, describes the evaluation's results for the military reader, emphasizing advantages that the CVCC system provides the unit commander. The first of the two companion reports (Leibrecht, Meade, Schmidt, Doherty, & Lickteig, in preparation) also focuses on operational issues, but is more technically oriented. The second companion report (Atwood, Winsch, Sawyer, & Ford, in preparation) addresses training and soldier-machine interface (SMI) issues. The latter report describes desired system refinements and training approaches identified by the users during the course of testing.

This report is organized into five sections, as follows:

1. Introduction - presents a statement of the problem (preceding); command and control background, digital communications and the CVCC project; purpose of the battalion evaluation; and hypotheses.

2. Method - examines the experimental approach; describes the CVCC system; explains procedures used during the evaluation; and describes the support staff.

3. Results and Discussion - presents data and findings relevant to command and control systems, maneuver, fire support, and intelligence gathering and dissemination.

4. Conclusions - recaps and analyzes key findings, and their implication for future applications.

5. Recommendations for further research - presents implications for future efforts.

Background

This subsection establishes the background of the battalion evaluation. It presents an overview of the Blueprint of the Battlefield and a short narrative on command and control, followed by a description of prior CVCC and related research.

Blueprint of the Battlefield

With the continuing evolution of the highly sophisticated modern battlefield, the Army created a blueprint to serve as a common framework for addressing battlefield operating systems (BOSs). The current Blueprint of the Battlefield (Department of the Army, 1991b) is a comprehensive, hierarchical listing of Army battlefield functions divided into three levels of war: strategic, operational and tactical. Each level of war focuses on a specific area so that staff and field organizations can relate Army needs to Army missions. The tactical level of war is the level at which battles and engagements are planned and executed, and involves formations at corps level and below. It is at this level that tactical units or task forces accomplish assigned military objectives. The tactical level is further organized into seven battlefield operating systems (BOSs) as shown in Table 1.

Table 1

Blueprint of the Battlefield: Tactical Level of War

Battlefield Operating Systems	
o Maneuver	o Intelligence
o Fire Support	o Mobility and Survivability
o Air Defense	
o Command and Control	o Combat Service Support

The BOSs also offer a suitable format for the evaluation of the CVCC system's operational effectiveness. To that end, specific research issues were developed to investigate CVCC's contribution within the tactical framework as described in the

Blueprint of the Battlefield. Throughout the battalion-level evaluation, command and control issues were the foremost concern.

Command and Control

Command and control (C^2), in its basic form, refers to the commander's ability to exercise authority and direction over assigned forces to accomplish the mission. It consists of various systems and procedures all directed toward successful accomplishment of the assigned mission while maintaining sufficient combat power for continued combat operations in accordance with the higher commander's intent (Department of the Army, 1988c).

Information on C^2 can be found in a variety of sources such as Army Field Manuals (e.g., Department of the Army, 1988c, and d), Army TTP publications (e.g., Department of the Army, 1990a and 1991), and in a variety of articles and papers published in Army periodicals. The TTPs provide the "how to" rather than the "what" that other doctrinal manuals provide. One of the main objectives of the C^2 system is to provide the commander information in order to make timely decisions during the conduct of the operation. Observations and conclusions from the U.S. Army's National Training Center (NTC) identify the critical relationship between effective C^2 and battlefield success. They emphasize that the commander must be able to "SEE" the battlefield through fast and accurate reports provided by subordinates and with the support of the tactical operations center (TOC) for information processing, planning, and coordination (Department of the Army, 1985).

Conventional C^2 techniques at the battalion and task force level are based on voice radios, and the use of written materials such as operations orders (OPORDs) and hand drawn overlays which are posted to mapboards or mapcases. These tools, though effective, require considerable time and effort to prepare, coordinate, publish, and disseminate. Updating and maintaining each of these also requires considerable effort and attention to detail which, during the heat of battle, could be overlooked, causing the loss of important information or the misunderstanding of instructions.

Using doctrine and training manuals, the commander determines what tasks are expected of the unit. TTPs offer proven methods that can be tailored to the situation to accomplish those tasks. The TTPs provide a common set of ideas on how to accomplish critical tasks. These ideas can be selected and adapted to a unit's mission, organization, expected area of operations, and personnel to form the basis for the unit's standing operating procedures (SOP). Extensive use of unit SOPs, along with brevity codes, battlebooks, and other tools that enable the unit to respond quickly to fragmentary orders (FRAGOs) or changes to the original order can often spell the difference between success and failure. The ability to pass information

quickly and accurately through other than voice media may enhance the commander's ability to see the battlefield and help direct the battalion or task force toward mission accomplishment.

Digital Communication and Horizontal Integration

Many of the shortcomings related to the conventional C^3 process have potential resolution through automated systems. For example: a system that would automatically post unit locations and reported enemy activity to map displays would help the commander maintain an accurate, up-to-date picture of the tactical situation within his battle space. Likewise, the ability to transmit text messages in lieu of voice transmissions would help reduce the likelihood that key words or phrases would be misunderstood or not received.

Digital technology offers a medium by which large amounts of data can be assembled and broadcast in a fraction of the time needed to transmit the same information verbally. Moreover, these data can be displayed automatically in varied formats, such as military graphics posted to a tactical map. This capability offers a reduction in the time a commander might otherwise spend posting that information to a paper map. Furthermore, the probability that automated data would be displayed inaccurately is much smaller than the margin for error associated with manually posted information. Finally, certain types of information (e.g., fuel levels and ammunition status) could be shared through entirely automated routines. When combined with a global positioning system that provides an accurate location for a combat vehicle, the system could post and periodically update the location of adjacent and subordinate vehicles or forces. Digital means could therefore allow a commander to monitor developments throughout his battle space from anywhere on the battlefield. In other words, the commander could obtain a more comprehensive and accurate perspective than he might using only conventional means.

Digital communication is not new to the battlefield. Within combat forces, the tactical fire direction system (TACFIRE) represents perhaps the most familiar application of digital communication. TACFIRE enables the fire support community to transfer reports, messages, and some graphics by digital means, to request, control and coordinate indirect fires. TACFIRE links forward observers (FOs), maneuver fire support teams (FISTs), and firing units with C^3 nodes throughout the fire support organization (Department of the Army, 1991a).

The Maneuver Control System (MCS) is another digital communication application that has been fielded to facilitate command, control and reporting at the tactical level of war. MCS is one of five battlefield functional systems of the Army tactical command and control system (ATCCS). MCS nodes at maneuver battalion level feed a network from brigade to corps levels (Association of the U.S. Army, 1992).

The Advanced Field Artillery Tactical Data System (AFATDS), a planned replacement for TACFIRE, will integrate fire support C^2 among mortars, field artillery, close air support, naval gunfire, attack helicopters and offensive electronic warfare systems. AFATDS will not only be multi-service (Army and Marine Corps), it will also be interoperable with German and British fire support systems (Association of the U.S. Army, 1992). AFATDS is a second functional system of ATCCS.

The Single Channel Ground and Airborne Radio System (SINCGARS) uses digital technology to encrypt, carry, and decrypt both voice and data transmissions. In its basic form, SINCGARS offers secure voice capabilities beyond those available with AN-VRC 12 series radio systems. Furthermore, SINCGARS is designed to support data transfer between and within tactical units (Communications-Electronics Command, 1987). This capability facilitates advanced C^3 applications at tactical echelons.

The M1A2 represents the first application of digital communications technology to tanks. Other improvements in sighting and navigation systems further enhance the M1A2 over its predecessor, but the digital communications capability contained in the M1A2 version of the intervehicular information system (IVIS) enables the commander to receive, process, and distribute combat data between tactical echelons from the individual tank up to the battalion command group (Department of the Army, 1993b).

IVIS provides both automated and user-generated data transfer capabilities among combat vehicles. This digital link enables networked systems to augment conventional voice traffic with automated tactical information (Department of the Army, 1992). A commander with a mix of both IVIS-equipped and conventional units must make a conscious effort to maintain effective communications between the two (Department of the Army, 1993b). Also, tactical information from IVIS must be manually transferred to the TACFIRE system in order to integrate indirect fires. Likewise, no automated link exists between IVIS and MCS. Furthermore, until IVIS (or a similar system) is expanded to other members of the combined arms team, voice radio communications and face-to-face contact will continue to provide the primary information-sharing media for tactical forces.

The Airborne Target Handover System (ATHS) provides a digital link between Army aviation systems, and includes call-for-fire protocols, compatible with TACFIRE, to facilitate indirect fire targeting from airborne forward observers (Department of the Army, 1990a). As such, ATHS integrates aviation and indirect fire systems. Still, this system is not integrated with either MCS or IVIS, and therefore relies on voice means for integration with other battlefield systems. In effect, ATHS acts as an interim accommodation pending the fielding of AFATDS.

The CVCC system represents a further development of automated C^3 systems. CVCC has an enhanced IVIS-like capability that features a mass memory unit, full-color tactical map with a complete array of terrain features, and a touch sensitive screen in the command and control display (CCD) at the commander's station. Also, CVCC includes additional message formats and capabilities over those provided by the M1A2's IVIS. The system also incorporates an enhanced CITV. Prior CVCC studies are summarized later in this report. System capabilities are outlined in Table 2. The CVCC system combines textual and graphic information, using common formats between combat vehicles and staff workstations,[1] sent and relayed via digital burst transmission. The collective capabilities of the CVCC system provide near real-time acquisition, processing, and dissemination of combat critical information.

Table 2

CVCC Capabilities

- Digital map with overlays
- Automated navigation
  - Route development and transmission
  - Driver's steer-to display
  - Friendly vehicle/unit locations
- Preparation, transmission, storage and retrieval of digital reports, routes[a], orders[b] and graphic overlays[b]
- Precise location inputs to digital reports
- Graphic display of key report information
- Automated status reporting: own vehicle and subordinates
- Enhanced commander's independent thermal viewer (CITV) with IFF function
- Battalion/task force staff workstations
- Secure digital burst transmission

Note. [a]Route functions are not available on TOC workstations. [b]Orders (freetext messages) and overlays can only be created or edited on TOC workstations.

Prior CVCC Research

The current CVCC effort is the culmination of a series of studies, sponsored by ARI, using Simulation Networking (SIMNET) technology as a vehicle to explore new combat systems and modifications to existing systems with individual vehicle simulators and actual crews. The majority of this work has been

[1]Staff or TOC workstations are used by the commander and staff in the TOC (as opposed to equipment in the simulator).

conducted in the Mounted Warfare Test Bed (MWTB)[2] at Fort Knox, KY. The MWTB is described in more detail in a subsequent section of this report. The narrative that follows summarizes the CVCC program and related research. A more detailed description is contained in Atwood et al. (in preparation). Table 3 provides a summary of related research efforts that led up to the CVCC system. Table 4 provides a summary of prior CVCC system evaluations.

Table 3

Summary of Previous CVCC-Related Research

<u>POSNAV Evaluation</u> (Du Bois & Smith, 1989). Individual tank level.

Findings -- Improved:
- navigation accuracy and efficiency
- map-terrain association
- ability to bypass obstacles
- reaction to enemy fires

<u>IVIS Evaluation</u> (Du Bois & Smith, 1991). Platoon level, POSNAV plus digital reporting.

Findings --
- faster/more effective mission accomplishment
- ability to locate friendly elements
- more accurate and timely reporting
- more effective obstacle avoidance
- more effective FRAGO execution
- more effective BP occupation

<u>CITV Evaluation</u> (Quinkert, 1990). Individual tank level.

Findings --
- improved detection and engagement of multiple threats

<u>POSNAV</u>. In one of the earliest evaluations in the MWTB, Du Bois and Smith (1989) compared the performance of crews using two different automated position/navigation (POSNAV) displays (grid and terrain map) and conventional navigation techniques on the SIMNET database. POSNAV provided each tank with a display of

[2] The MWTB was originally known as SIMNET-D (Developmental), and later, the Close Combat Test Bed (CCTB).

that tank's own position and heading. The study found that POSNAV enabled crews to navigate more accurately and efficiently. Moreover, POSNAV crews were better able to perform map terrain association, bypass obstacles, and react to enemy fire.

IVIS. Another important step in the development of automated C^3 occurred with an evaluation of IVIS. IVIS functionally combined POSNAV features from the previous effort with digital report capabilities. Du Bois and Smith (1991) reported that IVIS-equipped crews executed missions more rapidly and effectively, reported more accurately and quickly, avoided or bypassed previously reported obstacles, executed FRAGOs, and occupied battle positions more effectively than Baseline crews. Most of the findings from the IVIS evaluation favored the navigation functions as opposed to the automated reporting capabilities, possibly due to the fact that the IVIS effort was limited to platoon operations. A follow on effort, focused at the company level, was recommended to further develop the reporting functions.

It is important to note that the IVIS version that Du Bois and Smith (1991) studied differed from the version applied to the M1A2 tank. Both IVIS versions shared many common functions, such as navigation features and digital information sharing. The differences (e.g., hardware and message formats), although notable, do not prevent the generalization of findings from the IVIS study to the potential performance of M1A2 units.

CITV. The CITV was evaluated separately using the Conduct of Fire Trainer (COFT). Quinkert (1990) reported that the CITV enabled crews to detect and engage multiple threats more rapidly than conventionally equipped crews. Recommendations from this study included the redesign of the commander's control handle, modifications to the CITV display, and implications for crew training.

CVCC company evaluation. In another study, CITV and an improved digital C^3 system were integrated along with the other enhancements mentioned in a preceding section, to form the initial CVCC configuration, and evaluated within the context of tank company operations. Leibrecht et al. (1992) found that CVCC-equipped companies completed both offensive and defensive missions more rapidly than Baseline units. The navigation function enabled units to shorten travel distances and reduce fuel use in both the offense and defense. The inclusion of the CITV resulted in enhanced target engagement performance among CVCC units. Digital reporting capabilities enabled CVCC-equipped units to generate more accurate and timely FRAGOs and CONTACT reports. FRAGO and intelligence (INTEL) report clarity was also improved by the digital capability. Furthermore, more timely displacements in delay situations were observed among CVCC units than among Baseline units. The company level evaluation demonstrated several needs, specifically: a means to reduce redundant reporting, a feedback mechanism to confirm message

Table 4

Summary of Prior CVCC Evaluations

CVCC Company Evaluation (Leibrecht et al., 1992).

Findings --
- faster mission execution
- less travel/fuel consumption to accomplish mission
- enhanced target engagement
- more accurate and timely FRAGOs and CONTACT reports
- improved FRAGO and INTEL clarity
- more timely displacement in delays

CVCC Battalion TOC Evaluation (O'Brien et al., 1992). Battalion-level operations, CVCC-compatible TOC workstations.

Findings --
- reduced commanders' workload re: monitoring and directing subordinates
- established foundation for battalion-level evaluation

CVCC Battalion Preliminary Evaluation (Leibrecht et al., 1993). Battalion level operations, Company XOs.

Findings --
- validated battalion evaluation model
- refined measures for battalion evaluation

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reception, and a free text capability. Also, the company level evaluation demonstrated the need to integrate digital communications between the maneuver elements and a TOC-based battle staff, in order to provide better information management and enhance tactical coordination to assist the commander's decision making process.

CVCC battalion TOC evaluation. The battalion TOC evaluation (O'Brien et al., 1992) built on previous CVCC efforts by extending the research to the battalion level. Automated TOC workstations enabled the battalion staff to communicate digitally with simulator-mounted unit commanders. The TOC workstations used CVCC-compatible report formats, with some enhanced capabilities. Specifically, the TOC staff could create tactical overlays and free text messages that could be transmitted to and relayed by the CVCC-equipped simulators. Unit leaders indicated that the CVCC system reduced their workload with respect to monitoring and directing subordinate units, but that the volume

of digital reports was a distraction. This work established the foundation for the current, battalion-level effort.

Purpose of the Battalion Evaluation

Earlier research evaluating CVCC technology began with individual components at lower echelons and progressed to the integrated CVCC system at the company and battalion TOC levels. The findings from the CVCC battalion TOC evaluation recommended numerous modifications and system interface adjustments for a more comprehensive battalion-level evaluation. A significant change to the participant structure from the TOC evaluation was the integration of company executive officers (XOs) to reduce the report processing workload on company commanders. A preliminary battalion evaluation was undertaken to verify this and other changes from the prior effort. Leibrecht et al. (1993) found the battalion evaluation model to be basically sound. The only recommended changes involved data analysis and presentation. In effect, the preliminary evaluation represents part of the current effort, Therefore, other facets of the test design (i.e., training program, unit structure and scenarios) were held constant from the preliminary evaluation to the current effort. This allowed the inclusion of the four test units from the preliminary evaluation in the database for the battalion evaluation (reported here), thus increasing the effective participant population for the battalion-level database.

At the battalion level, several questions are of direct interest: How does the CVCC experimental configuration impact the combat performance of battalions, especially in the context of operational effectiveness? What improvements are necessary to optimize utilization by unit commanders and TOC personnel? Will new TTPs be needed to optimize system performance? How will the CVCC system affect requirements for training armor unit leaders and crews?

These questions set the stage for the battalion evaluation, designed to establish a database to help guide doctrine, training, and design decisions and concepts for utilizing the CVCC system in a mounted warfare environment. Based on the questions of interest, the planning and execution of this evaluation incorporated three overall objectives:

(a) Evaluate the operational effectiveness of armor battalions using the CVCC experimental configuration, compared to conventionally-equipped battalions.

(b) Investigate operational training issues and concerns associated with the CVCC system.

(c) Identify critical SMI concerns and make recommendations regarding CVCC design and utilization.

Each of these objectives formed the basis for specific research issues. In generating the research issues linked to the operational effectiveness objective, the Blueprint of the Battlefield (Department of the Army, 1991b) provided an established doctrinal basis. As explained in a preceding section, the seven BOSs provide a framework for organizing tactical activities.

The CVCC system, as modelled in the current effort, has eventual implications for all seven BOSs. However, this evaluation did not focus on air defense, mobility and survivability, or combat service support (CSS) issues. The decision to exclude those systems in the battalion level evaluation was primarily made due to the limitations of the current simulation system and the CVCC software. The number of opposing force (OPFOR) aviation and friendly force (BLUFOR) air defense assets (i.e., SAFOR) necessary to adequately evaluate the air defense system would have over stressed the simulation capability available to support the battalion evaluation. With respect to the Mobility and Survivability BOS and the Combat Service Support BOS, the way that combat engineer and service support assets were simulated was not compatible with the rest of the test unit organization. Furthermore, scenario modifications needed to effectively integrate engineer and CSS operations would have extended the length of the scenario beyond the time available. In effect, the inclusion of air defense, mobility and survivability and CSS systems was not practical within the battalion evaluation. Therefore, only CVCC's potential contributions to the remaining four BOSs were considered for this evaluation.

Although the air defense, mobility and survivability, and combat support systems were not evaluated in this effort, operations within each of these systems were integrated within the scenarios. The scenarios assumed BLUFOR air superiority within the battalion's battle space, yet air defense assets were notionally operating in direct support (DS) of the battalion. Although no engineer assets or obstacles were active in the simulation, engineers were also notionally operating DS to the parent brigade, and a notional obstacle system existed. Likewise, although CSS operations were not included in the scenarios, the units' operational status (i.e., equipment and ammunition levels) was a constant factor during combat operations, and units were resupplied and refitted at predetermined points in the scenario. Furthermore, information pertinent to these BOSs was integrated at various points to influence the scenario's progress.

Within the command and control, maneuver, fire support and intelligence BOSs, the battalion level CVCC research was undertaken to identify key areas where the CVCC system was expected to improve performance relative to the Baseline system. The issues were stated as follows:

1. Does the CVCC system enhance the command and control BOS?

2. Does the CVCC system enhance the maneuver BOS?

3. Does the CVCC system enhance the fire support BOS?

4. Does the CVCC system enhance the intelligence BOS?

These issues formed the primary focus of this report. Other research issues were associated with the training and SMI objectives. The following issues addressed information needed to further understand performance effects related to the operational effectiveness issues and to evaluate the training and SMI requirements. These issues are evaluated by Atwood et al., (in preparation):

5. What training considerations and implications are important in training unit commanders and crews to operate and utilize the CVCC?

6. What SMI factors critically affect utilization of the CVCC configuration, and how do they impact future CVCC design?

In summary, the battalion evaluation sought to address a variety of issues relevant to CVCC equipment design and employment. This report will address BOS-based issues further described in the following section.

Hypotheses

The issues previously identified serve as a basis for these hypotheses, which state the expected performance of CVCC-equipped units as compared to conventionally-equipped units, hereafter referred to as Baseline units. Functions and/or subfunctions of each BOS, as identified in the Blueprint of the Battlefield (Department of the Army, 1991b), are used to organize supporting hypotheses. The functions and subfunctions that identify the detailed hypotheses will, throughout the remainder of this report, be generically referred to as "functions" or, if greater clarity is required, "BOS-based functions." Discussions in this section explain how the hypotheses relate to the tactical blueprint (Department of the Army 1990c), and describe how the CVCC system could enhance the battalion's operational effectiveness.

Global hypothesis. The operational effectiveness of CVCC-equipped battalions will be greater than that of units using conventional C^2 methods. That is, CVCC systems were expected to provide leaders and crews with a more accurate picture of both the friendly and the reported enemy situation throughout the unit's area. Digital communications were expected to improve both the synchronization and the protection of the friendly force, and to speed decision cycles as the unit reacted to

changing missions. Improved sensors (i.e., the CITV) are expected to improve target processing and engagement performance.

Command and Control BOS

Hypothesis. CVCC-equipped battalions will command and control subordinate units more effectively than Baseline battalions. The Blueprint of the Battlefield describes five C^2 functions: (a) acquire and communicate information and maintain status; (b) assess situation; (c) determine actions; (d) direct and lead subordinate forces; and (e) employ tactical command, control, and communications countermeasures (C^3CM).

Because of simulation, measurement, and design limitations, two of those functions (determine actions and employ tactical C^3CM) are not appropriate for investigation in this effort. Hypotheses relevant to two of the remaining functions (assess situation, and direct and lead subordinate forces) were established, and four separate hypotheses were developed from the remaining function, in order to investigate discrete elements of information communication requirements. Together, the results within each of these functions may show whether CVCC equipped battalions exercised more effective command and control than Baseline units.

The potential advantages afforded by digital communications were expected to simplify the unit's ability to communicate information, and to manage means of communication, both C^2 subfunctions. Three forms of information (mission, enemy information, and friendly troop information) accommodated the further categorization of supporting hypotheses, as indicated below.

Receive and transmit mission. CVCC-equipped battalions were expected to relay FRAGOs more quickly and more consistently across echelons than Baseline battalions. Voice FRAGOs typically take longer to transmit than digital messages, while transcription errors and other factors may modify the content of a voice FRAGO that a company commander relays to his subordinates. By contrast, a digital FRAGO can be relayed exactly as it was received. As a result, CVCC was expected to enhance FRAGO dissemination and interpretation during fast-paced operations.

Receive and transmit enemy information. CVCC-equipped units were expected to relay enemy information more rapidly and more accurately than Baseline units. Within the context of the battalion evaluation, this task focused primarily on the receipt and relay of enemy information from higher to lower echelons. As with FRAGOs, perfect consistency was expected for relayed digital messages. As such, commanders were expected to maintain better awareness of the enemy situation throughout their battle space in the CVCC condition.

Receive and transmit friendly troop information. Status reports from CVCC-equipped units were expected to be more accurate and timely than those from Baseline units. Given automated, real-time position and status reporting (i.e., location, ammunition, equipment, fuel and personnel), more accurate and timely performance was anticipated in the CVCC condition. As a result, commanders in the CVCC condition were expected to have a better understanding of their own units' situation.

Manage means of communicating information. CVCC-equipped units were expected to manage communications more effectively than Baseline units by significantly reducing their voice radio signature.[3] Also, units were expected to strike an effective balance between voice and digital traffic in the CVCC condition, and to maintain an effective division of labor for relaying reports. Digital messages were expected to reduce the likelihood that a commander would require verbal repetition or clarification of previously transmitted reports or orders.

Assess situation. The combination of automated position and status reporting, and user-generated reports provided the commander an up-to-date, graphic display of the tactical situation throughout his battle space. These displays, augmented with voice communications, were expected to improve the commander's awareness of the battalion's overall situation.

Direct and lead subordinate forces. CVCC-equipped units were expected to provide more effective direction to subordinate forces than Baseline units. The system's integrated tactical display was expected to provide a more comprehensive and timely picture of the tactical situation (both enemy and friendly) as compared to the Baseline. This improved situational awareness would enable the commander to better determine what refinements or changes might be necessary to the current plan in order to achieve success. Digital message capabilities were expected to enhance the commander's ability to communicate changes, and to monitor the course of the battle throughout his area of operations. These factors were expected to provide the commander more positive control over his subordinates.

Maneuver BOS

Hypothesis. CVCC-equipped units will maneuver more effectively than Baseline units. the three Maneuver functions are: (a) move; (b) engage the enemy; and (c) control terrain. The real-time displays of friendly unit positions and the automated reporting features inherent to the CVCC condition were

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[3]The impact of digital communications on FM transmissions was not evaluated in the current effort. See the description of the test system, and limitations subsections of the method section.

expected to improve a unit's ability to accomplish each of these functions. Furthermore, the CITV was expected to allow improved target processing within each crew. The supporting hypotheses within this BOS are taken from all three maneuver functions.

The first two supporting hypotheses are gleaned from the Move function. This function is concerned with the positioning or repositioning of forces relative to the enemy to secure or retain positional advantage over the enemy (Department of the Army, 1991b). The reader is cautioned that the move function corresponds to the definition of maneuver stated in FM 100-5, Operations (Department of the Army, 1993a), which distinguishes between maneuver and firepower as dynamics of combat power.

<u>Move on surface</u>. CVCC-equipped units were expected to move more effectively as a unit, and to control their exposure to enemy fires more effectively than were Baseline units. The POSNAV features allowed commanders to maintain an accurate understanding of their subordinates' locations, without frequent verbal reports, and without having to rely on direct observation. Furthermore, as units moved, CVCC units were better able to key on each other to maintain formation, even when out of line-of-sight contact. The tactical map display was expected to make it easier for commanders to shield their unit's movement from reported enemy locations.

<u>Navigate</u>. CVCC-equipped crews were expected to navigate more effectively than Baseline crews. At the individual crew level, the navigation component of the CVCC system simplified navigational tasks. As a result, crews were expected to move more rapidly and efficiently throughout the battlefield.

Two hypotheses are formulated from the function, "engage the enemy" (i.e., subfunction, "employ direct fire").

<u>Process direct fire targets</u>. Due to the CITV, CVCC-equipped crews were expected to process direct fire targets more effectively and efficiently than Baseline crews. This hypothesis is consistent with the results reported by Quinkert (1990) and Leibrecht et al. (1992). However, this affect was expected to be tempered within the context of the battalion evaluation. All vehicle (tank) commanders (TCs) in the current evaluation were cast in leadership roles (i.e., commanders, operations officer (S3), and company XOs). Therefore, C^2 requirements were expected to claim most of a TC's attention in both the Baseline and CVCC conditions. It is also possible that commanders would use the CITV for alternate purposes, such as monitoring the movement and formation of subordinate platoons. As a result, TCs were not expected to spend as much time searching for targets as TCs at platoon level or below. Instead, it was expected that gunners would independently acquire and identify targets. Since the CVCC and Baseline gunners' positions are essentially the same, the potential advantages from the CITV were not expected to be realized among command tanks. By contrast, this and the

following hypothesis also offer a means to determine whether the CVCC system might claim too much of the crews' collective attention as compared to conventional C^2 techniques, and therefore hamper crew level performance.

Engage direct fire targets. CVCC-equipped units were expected to more effectively engage opposing forces with direct fires than were Baseline units. The CVCC system allowed units to rapidly share accurate enemy and friendly information in graphic form. This capability could be exploited to coordinate and mass direct fires on the enemy.

Control terrain. CVCC-equipped units were expected to control terrain more effectively than Baseline units. The improved situational awareness attributed to the CVCC system was expected to enhance the unit's control over key terrain within the area of operations. That is, by enabling the unit to more effectively coordinate combat operations, commanders at each level (i.e., battalion and company) would be better able to assess the degree of control their unit exerted over the terrain in their battle space, and direct subordinates accordingly.

Fire Support BOS

Hypothesis. CVCC-equipped units will employ indirect fires more effectively than Baseline units. The tactical blueprint describes three fire support functions: (a) process ground targets; (b) engage ground targets; and (c) integrate fire support (Department of the Army, 1991b). The latter two functions involve actions that tank battalion commanders do not normally influence, except with respect to the organic mortar platoon. However, given the extent to which the Fire Support Officer (FSO) controlled the mortar platoon in the simulation, participants were only rarely directly involved with those functions. The only function that involved participants was the decision to engage enemy formations with indirect fire means, reflected by a participant-generated call for fire (CFF). This decision process is inherent to the "process ground targets" function, and therefore forms the basis for the analysis of CVCC's contribution to the fire support BOS within the current effort.

The ability of a CVCC-equipped crew to determine precise enemy locations using the laser range finder led to the expectation that CFFs would be more accurate in the CVCC condition. However, given that targets were viewed through the same sights in both conditions, target description accuracy was not expected to differ between conditions, except as influenced by better resolution through the CITV.

Intelligence BOS

Hypothesis. CVCC-equipped units will more accurately report combat-critical enemy information than will Baseline units. The

tactical blueprint identifies three intelligence functions: (a) collect information; (b) process information; and (c) prepare intelligence reports. The current effort was not directly concerned with the "process" and "prepare report" functions, in that those functions were more appropriate to activities within the contractor-operated TOC (see Method). The critical factor that participants were concerned with was the collection of information, evidenced by critical tactical reports (i.e., SPOT, CONTACT, and SHELL reports). As with CFFs, positional accuracy was expected to be greater in reports rendered by CVCC units as compared to Baseline units, as was the accuracy of target descriptions.

Method

The following narrative explains the design of the battalion evaluation. The Approach section addresses the research design, the test unit configuration, and the soldiers that participated in the evaluation. The CVCC system description explains the equipment that was used to support the evaluation in general, and the Baseline and CVCC configurations of the M1 simulators, the battalion TOC, the SAFOR, and other forces included in the simulation. The Procedures section explains the training program that prepared participants for the test scenario, the tactical scenario used during the data collection itself, exercise control procedures, and data collection procedures. The Support Staff section describes the organization and responsibilities of the research staff during test weeks. The final subsection describes the operationally meaningful limitations of this simulation-based research.

Approach

Overview

The battalion evaluation compared performance between units using condition as the primary independent variable. The four-day schedule, unit structure, and tactical scenarios were generally held constant between conditions. There were some differences in the individual and crew training programs, which were tailored to the condition. A total of twelve groups participated in the evaluation. Each battalion group was assigned either to the Baseline or the CVCC condition. Six groups served in each condition.

Besides the primary independent variable (condition) a secondary independent variable and an incidental variable were also included in the test design. Participants served as battalion and company command groups to form the secondary independent variable: echelon (i.e., battalion commander and S3 at the battalion echelon and company commanders and XOs at the company echelon). The test scenario was divided into three distinct tactical stages: two delay stages (defensive framework), and one counterattack (offensive framework). The incidental

variable, stage, was used in order to group data separately for each tactical situation. The data for the stages were analyzed separately, but no statistical comparisons were intended between stages. A more thorough explanation of the test scenario may be found in the Procedures section of this report. Leibrecht et al. (in preparation) offer a more detailed explanation of the research design.

Unit Configuration

Although the CVCC system is adaptable to a variety of combat vehicles, the developmental process has been limited to a single platform (i.e., M1 series tank). The current effort is therefore focused on a tank battalion as opposed to a battalion task force. The test unit was identified as the 1st Battalion 10th Armor, an element of 1st Brigade, 23rd Armor Division. The brigade also contained two infantry (IN) battalions (1-91 and 1-92), and a typical brigade slice of combat support (CS) and combat service support (CSS) assets. The brigade's task organization for the test scenario is shown in Table 5.

Table 5

Brigade Task Organization

1-91 IN (M)	Bde Control
	1-50 FA (155mm, SP) (DS)
	A/1-440 ADA (-) (V/S) (DS)
	A/23 ENGR Bn (OPCON)
1-92 IN (M)	1/A/23 MI Bn (C&J) (DS)
2/A/1-440 ADA (DS)	1/1/B/23 MI Bn (GSR)
	2/1/B/23 MI Bn (GSR)
	1/23 MP Co
	45 CHEM Co (SMK/DECON) (-) (DS)
1-10 AR	2/48 CHEM Co (SMK) (-) OPCON
1/A/1-440 ADA (DS)	
	Bde Trains
	1 FSB (DS)

<u>Test unit task organization</u>. As a J-Series tank battalion, the test unit was assumed to have four line companies of fourteen M1 series tanks each, a scout platoon of six M3 Bradleys, and a heavy mortar platoon with six 107 mm mortars mounted in M106 mortar carriers (Department of the Army, 1988c). The normal complement of command and control, utility, cargo, and special purpose vehicles was assumed, as well as liaison and direct support assets allocated from Brigade.

Because the test unit was operating as a tank-pure battalion, the four line companies were deployed without cross-

attachments. The scout platoon, mortars, and direct support air defense element were all controlled at the battalion level. The battalion's CSS assets and the supporting Mobile Support Team (MST) were handled notionally. Figure 1 graphically represents the test unit structure.

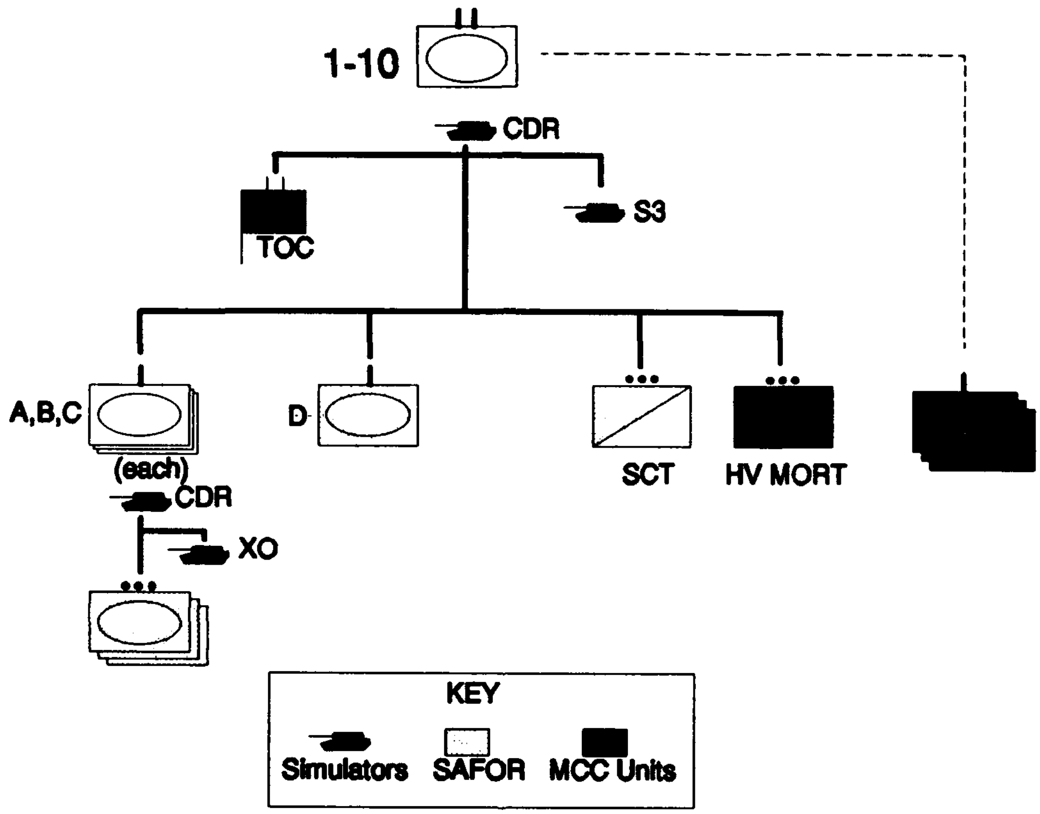

Figure 1. Test unit structure.

<u>Superior, adjacent, and supporting units</u>. With two exceptions, all friendly elements outside of the test unit were represented notionally. The exercise control staff assumed the roles of the brigade commander, brigade staff, adjacent unit commanders, and liaison officers. The first exception was the three firing batteries (eight guns each) of the direct support (DS) field artillery (FA) battalion. These were represented through the Management Command and Control (MCC) system (see Description of the Test System), were moved by the Battle Master, and were assigned fire missions by the FSO. The second exception was a tank company (represented by SAFOR) from an adjacent unit that was passing through the battalion's area of operations at the outset of the test scenario.

<u>Organic units</u>. Within the battalion, only the line companies, the scouts, the mortar platoon, the command group, and

the TOC appeared within the simulation. All other CS and CSS elements were notional. The eight manned simulators were allocated to the battalion commander, the S3, and the commanders and executive officers (XOs) of A, B and C Companies. The three line platoons of A, B and C Companies, all of D Company, and the scout platoon were represented with semiautomated forces (SAFOR). The SAFOR were operated by two SAFOR operators who responded to commanders' orders and directions. The battalion staff were represented by four civilian personnel (battalion XO, S2, assistant S3, and FSO) that operated out of an M577 extension in the simulator bay. The TOC was graphically represented within the simulation by three M577s and an M2 that were generated by the MCC. The mortar platoon's vehicles were also generated by the MCC. Company executive officers assumed the additional duty of Fire Support Team (FIST) chief.

Participants

General. A total of 282 U.S. Army personnel and one marine[4] participated in the battalion evaluation. These personnel included 95 officers and 188 non-commissioned officers (NCOs) and enlisted men stationed at Fort Knox, Kentucky. Participants ranged in age from 19 to 43. All participants held an armor Area of Concentration (AOC) or were currently qualified in armor Military Occupational Specialties (MOSs). The staffing model is shown in Table 6. With the exceptions noted below, eight officers and sixteen NCOs and enlisted men supported each of the twelve test weeks (six Baseline and six CVCC conditions).

Table 6

Participant Staffing Model

Number	Position	Qualifications
1	Bn Cdr	(LTC or MAJ, AR)
1	Bn S3	(MAJ or CPT, AR)
3	Co Cdrs	(CPT or 1LT, AR)
3	Co XOs	(1LT or 2LT, AR)
8	Gunners	(SGT or CPL, 19K)
8	Drivers	(CPL or PFC, 19K)

For a variety of reasons, test groups did not always include a complete set of participants. Contingency rules from the test support package (Sawyer, Meade, Ainslie, and Leibrecht, in preparation) dictated the priority for duty assignments given

[4]An armor-qualified Marine major assigned to the USAARMS faculty served as the battalion commander for a Baseline rotation.

missing personnel. The data included in the results and discussion section are modified to accommodate missing participants.

It would have been preferable to draw each participant group from line tank battalions, and to organize crews based on established battle rosters. However, this was not possible. In almost all cases, the entire test group had to be organized ad hoc using available personnel that were tasked from training, school, and combat units at Fort Knox. The following figures provide selected data regarding participants' qualifications. Additional data are tabulated in Appendix B.

Figure 2 shows the distribution of participants by rank. All battalion commanders were majors, and all but one battalion S3 were captains. Only during one test week (CVCC condition) were there two field grade officers available for the battalion command group. Most of the company commanders were captains. As shown in Figure 2, the Baseline population included a higher number of NCOs in the ranks of sergeant first class (SFC) and staff sergeant (SSG).

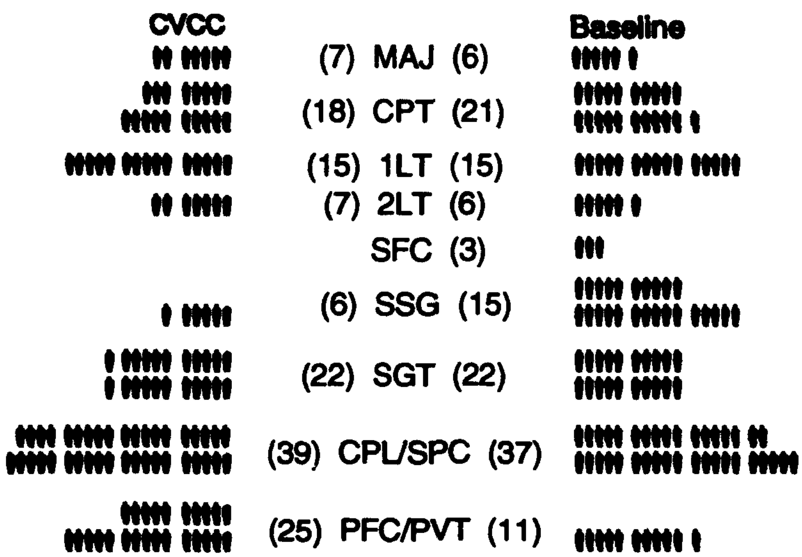

Figure 2. Participant distribution, by rank.

<u>Service experience</u>. Total service experience and experience in Armor units serves as a general indicator of group comparability. Overall, experience levels among officers were comparable, whereas the average experience level among NCOs in Baseline groups was greater than among CVCC groups (see App. B., Table B-1).

<u>Experience in selected duty positions</u>. Figure 3 shows the distribution of participants by current duty position. The number of officers currently assigned as company commanders and

XOs and to instructor duties slightly favors the Baseline condition. Likewise, the number of NCOs currently serving as TCs and instructors favors the Baseline condition. By contrast, the number of NCOs and enlisted personnel currently assigned as gunners and drivers favors the CVCC condition. It should be noted, however, that this distribution does not reflect prior experience levels.

CVCC	Officers	Baseline
(1)	Bn XO	(1)
(1)	Bn S3	(1)
(6)	Co Cdr	(10)
(8)	Co XO	(11)
(8)	Plt Ldr	(6)
(1)	Instructor	(4)
(7)	Student	(1)
(15)	Other	(14)
	NCO/Enlisted	
(3)	Tank Cdr	(11)
(32)	Gunner	(23)
(40)	Driver	(23)
(3)	Instructor	(18)
	Student	(3)
(9)	Other	(14)

Figure 3. Participant distribution by current duty position.

Besides current assignment, experience levels in selected positions are important in characterizing the participant group's background (see App. B., Table B-2). The data show roughly comparable levels of experience at the battalion level (battalion commander, XO and staff) and company level (company commander, XO, and platoon leader) among officers, although the number and cumulative experience of officers that have served as a battalion S3 are roughly twice as great in the CVCC condition. The number of NCOs with experience as platoon sergeants was three times as great in the Baseline condition, and the cumulative experience was better than four times as great in the Baseline condition. At the tank commander level, the number of participants was roughly double, and the cumulative experience better than three times as great among the Baseline group. The number of NCOs and enlisted participants experienced as gunners was only about 20%

greater in the Baseline condition, but the cumulative experience was nearly 50% greater.

Military schooling (App. B., Table B-3). The Baseline group had a greater percentage of graduates at all military school levels among NCOs and enlisted personnel, and all but Command and General Staff Officer's Course (CGSOC) among officers. The Baseline group had better than twice as many Combined Arms and Services Staff School (CAS3) and Basic Non-Commissioned Officers Course (BNCOC) graduates, better than three times the number of Advanced Non-Commissioned Officers Course (ANCOC) graduates, and nearly 50% more Primary Leadership Development Course (PLDC) graduates than the Baseline group.

Description of the Test System

This section summarizes the test equipment used by participants and the control staff to execute and control training and testing. It also lists additional equipment used to collect and analyze the data from the evaluation. More detailed descriptions can be found in Leibrecht et al. (in preparation) and Atwood et al. (in preparation).

MWTB Test Equipment

MWTB equipment used in this evaluation included M1 simulators, battalion TOC workstations, SAFOR workstations, simulation control consoles, displays for monitoring the battlefield, simulation utilities consoles, an automated data collection system, and a data reduction and analysis subsystem. Each of these components transmitted and received information over a coaxial cable Ethernet computer network. More complete facility descriptions appear in previous CVCC publications, especially O'Brien et al. (1992).

M1 Simulators

For this evaluation, MWTB M1 tank simulators were used in both the Baseline and CVCC conditions. The SIMNET M1 simulators were modified to accommodate changes in the crewstations for commander, gunner and loader to simulate CVCC capabilities. MWTB simulators did not include all functions and controls found in an actual M1, but only those necessary to fight the tank. This was consistent with the "selective fidelity" concept used to develop cost effective simulators (U.S. Army Armor School, 1989). Table 7 summarizes the Baseline and CVCC simulator configurations.

Baseline Simulator. The Baseline simulators contained selected controls, indicators and sights available on an M1 tank. Some features of the tank were not represented in the simulation, and therefore the controls corresponding to those capabilities were represented by decals on the simulator wall. For example: smoke was not available in the simulation, therefore the smoke

Table 7

M1 Simulator Configuration

Baseline	CVCC
Standard SIMNET M1 simulator, plus: o Thermal Imaging System (TIS) o Autoloader (40 round basic load) o SINCGARS radio	Baseline M1 simulator, plus: o CCD o CITV

grenade launcher controls on the TC's control panel were merely decals.

Several design limitations of the standard simulator are noteworthy to the extent that they effect crew performance as compared to an actual, M1 series tank. These are mentioned here in only a general sense. Related SIMNET publications (e.g., the SIMNET User's Guide, U.S. Army Armor School, 1989, and the M1 SIMNET Operator's Guide, U.S. Army Armor School, 1987) will provide the reader greater detail on these limitations. Specifically, the simulator emulates a closed-hatch mode, and offers only a limited view from the commanders hatch. This limitation affects conventional navigation and formation-keeping performance. The former problem is offset, to some extent, by the addition of simulator-unique navigation tools. Also, the simulator only emulates the main gun and its primary direct fire system. That is, the gunner only has the gunner's primary sight (GPS) available. Unlike the standard SIMNET M1 simulator, the simulators used for this evaluation also emulated the TIS channel in both the GPS and gunner's primary sight extension (GPSE).

Ammunition handling was simulated by an automatic loader (autoloader) and ammunition transfer controls at the TC's position. The autoloader was incorporated to vacate the loader's position for a research assistant (trainer/monitor). The autoloader took approximately eight seconds to reload after a round was fired. If a round was already chambered and the gunner changed the ammo selection, the autoloader took approximately eleven seconds to clear the breach and load the new round. The TC could transfer ammunition from the semi-ready rack to the ready rack by using a switch on the turret wall. Simulators began each scenario stage with a basic load of 27 sabot and 13 HEAT rounds, to simulate a 120mm gun configuration.

A simulated tactical radio network provided communication capabilities. Each simulator was equipped with two SINCGARS radio simulators. The radios converted voice transmissions into

digital signals, which were broadcast over the simulation Ethernet. This capability also made it possible to capture voice transmissions along with simulation data broadcast over the Ethernet. An intercom system provided for communication between crewmembers. Maximum effective radio communication distance was unlimited.

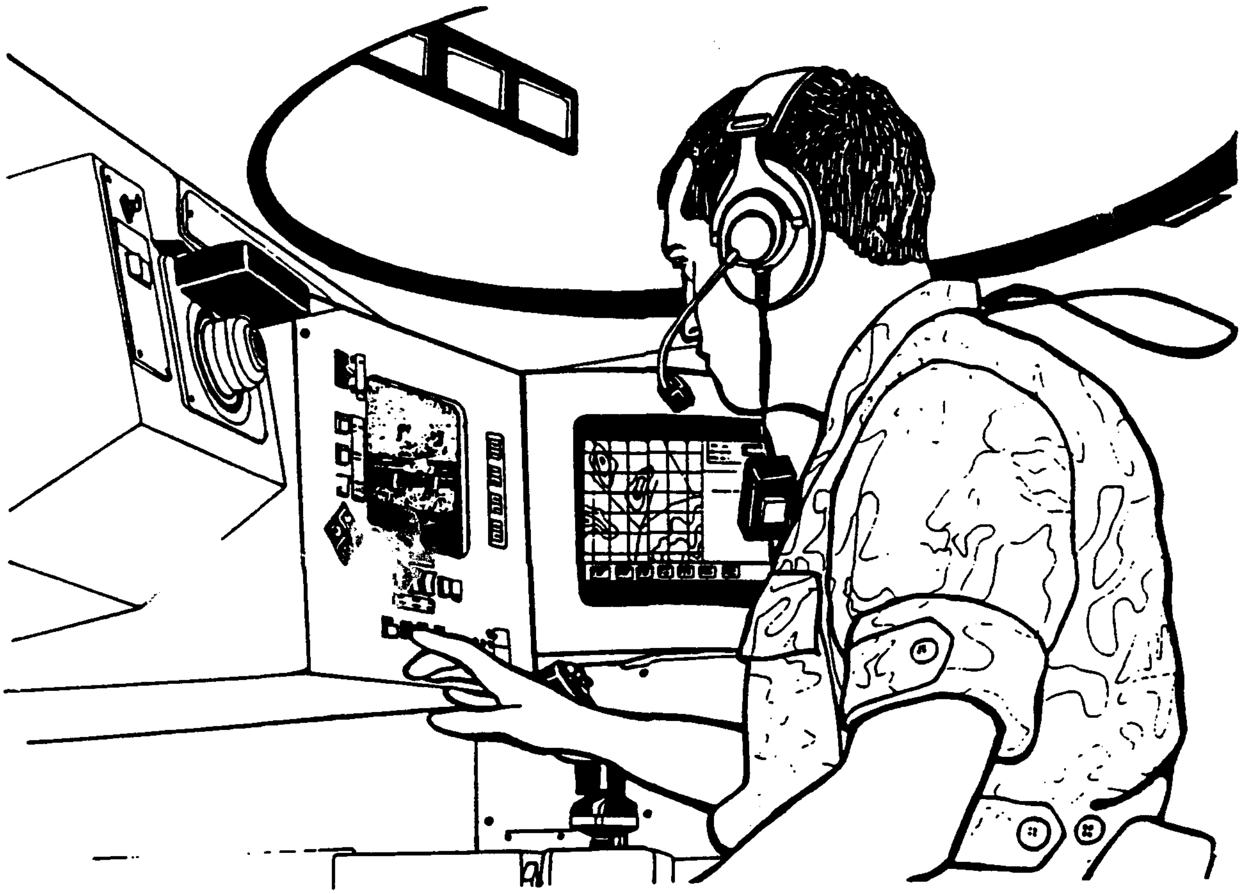

Figure 4. CVCC Commander's Station.

CVCC M1 simulators. In addition to the basic M1 simulator hardware and software described in the previous paragraphs, simulators configured for the CVCC condition included several other major capabilities. The CCD, and CITV were the major components which distinguished the CVCC M1 from the Baseline M1. Figure 4 illustrates the commander's station in the CVCC simulator, with the CCD to the vehicle commander's right, and the CITV to his front (between the GPSE and CCD). Table 8 summarizes the CVCC simulator's capabilities.

The CCD was the primary interface used to receive, transmit, and display digital messages. The CCD's capabilities are listed in Table 9. The display was dominated by a map screen and

Table 8

CVCC Simulator Capabilities

C^2	Target acquisition and engagement
CCD with: o Digital map o Digital messages o Location of own forces o Status of own tank and subordinate units	CITV with: o laser range finder (LRF) o 3 scan modes o 3X and 10X magnification o white hot/black hot polarity o target designate
Navigation	**Communications**
o Digital terrain map and tactical overlays o Digital navigation routes o Driver's steer-to display	Digital burst transmissions of: o combat reports o tactical overlays o navigation routes

Note. Capabilities listed are unique to the CVCC configuration.

variable menu area. Other parts of the screen were dedicated to function keys and permanent information displays. The screen was manipulated using a touch screen and/or a thumb cursor on the commander's control handle. When preparing reports, locations could be entered using the touch screen, thumb cursor, or the vehicle's laser range finders (LRF). CCD reports that included locations automatically posted a position icon to the map screen when the report was in the receive queue, open, or posted to the map by the commander. A more detailed description of the CCD and its capabilities may be found in O'Brien et al. (1992).

The CCD is designed to receive and transmit digital data through the radio interface unit (RIU) of the SINCGARS radio. However, the RIU was not implemented for the current evaluation. Instead, digital messages were routed directly between the CCD's host computer and the simulation Ethernet.

The navigation component allowed the commander to monitor the position of his own vehicle, as well as adjacent and subordinate units. It was also used to create navigational routes. The navigation module included a steer-to display at the driver's position that displayed the direction and distance to the waypoint designated on the CCD. The driver could then navigate the tank to that location using minimal verbal communication with the TC. The TC could designate a sequence of waypoints (i.e., a route), and set the navigation module in an auto-advance mode, so that the display would advance to the next waypoint when the tank came within 100 meters of the current

Table 9

CCD Capabilities

Input Options o Thumb (cursor) control o Touch screen input o Laser range finder location input to combat reports
Navigation o Digital tactical map with selectable grid lines, scales, and terrain features o Digital tactical overlays o Own-vehicle location (grid and icon) o Own-vehicle orientation (azimuth heading and directional icon) o Friendly vehicle location icons o Report-based icons o Graphic navigation routes with waypoints and storage/retrieval o Navigation waypoint auto advance o Driver's display (with steer-to-indicator)
Digital Communication o Combat report preparation o Send/receive/relay combat reports (including report icons) o Receive/relay tactical overlays o Send/receive/relay navigation routes o Friendly vehicle locations (mutual POSNAV) o Automated logistics reports, with auto routing

destination. Routes could be saved to a file and transmitted like other CCD messages.

All CCD reports except the logistics report could be sent on demand. The logistics report represented a special report category. When accessed, the logistics report showed the current status of one's own vehicle and any subordinate units. The user could obtain the equipment, personnel, ammunition, or fuel status of his unit, or the summary status (all four areas) of his own vehicle. This report was current when accessed. If the report remained open, the CVCC system would update it automatically based on both time and status criteria.

The CITV provided the commander with an independent battlefield viewing capability and an independent LRF. The reader should note that the CITV modelled in the battalion evaluation differed from the CITV that is employed in the M1A2 system. Table 10 summarizes the CITV capabilities within the CVCC system.

The CITV display was mounted directly in front of the vehicle commander, and the sensor operated independently of the turret. CITV controls were located on the CITV display panel and the commander's control handle. The CITV tank icon, located at the bottom center of the CITV display, contained separate components showing the orientation of the CITV, the main gun, and

Table 10

CITV Capabilities

o Independent viewer with LRF
o 3X and 10X magnification
o White-hot and black-hot polarity
o Target designate (main gun slew to CITV line of sight)
o Manual search mode
o Autoscan mode
o Gun line of sight (GLOS) mode (CITV slew to main gun line of sight)
o Identification Friend or Foe (IFF)
o Own vehicle icon (directional, all parts moving)

the tank hull, with the 12 O'Clock position always representing grid north. The CITV tank icon also displayed left and right sector limits that were used with an autoscan mode. The CITV had three operating modes:

(a) In the manual search mode, the commander manipulated the sight using the commander's control handle.

(b) In the autoscan mode, the sight automatically oscillated between pre-set sector limits. The TC could adjust both the sector limits and the scan rate.

(c) In the gun line of sight (GLOS) mode, the CITV was slaved to the gunner's primary sight in both azimuth and elevation.

In the autoscan and GLOS modes, the TC could override the CITV and revert to manual control by depressing the palm switch on the commander's control handle. The TC could also designate targets (bringing the gun tube on line with the CITV) whenever he was operating in manual mode.

The CITV included an Identification Friend or Foe (IFF) system that was activated with the CITV LRF. When the commander lased at any vehicle using the CITV, an IFF symbol appeared in the upper left corner of the CITV display. IFF system accuracy varied from 40-90 percent, based on the range to the target. Gunners were still required to visually confirm targets prior to engaging.

Tactical Operations Center

In addition to the vehicle simulators, a battalion TOC supported tactical operations in both the Baseline and CVCC conditions. Both the Baseline and CVCC TOCs contained stand-

alone SINCGARS radio simulators compatible with those in the simulators. In the CVCC condition, automated TOC workstations extended the capabilities available in the CVCC M1 simulators. Table 11 compares the Baseline and CVCC battalion TOCs.

Table 11

Battalion TOC Operational Requirement

Baseline TOC	CVCC TOC
o Conventional mapboards and status displays	o Four Bn TOC workstations
o Acetate overlays	o Large screen SitDisplay
o Paper message transcripts and journals	o FSE terminal
o Fire support element (FSE) terminal	o SINCGARS radio simulators
o SINCGARS radio simulators	

<u>Baseline battalion TOC</u>. The Baseline TOC was located in a single M577 extension. Battle reports, unit locations and status, and other pertinent information were maintained on wall charts and maps. The TOC staff maintained staff journals manually. Radios were configured for voice communication over the brigade command net, brigade operations and intelligence (O&I) net[5], the battalion command net and the battalion O&I net[6]. See Leibrecht et al. (1993) for a more detailed description of the Baseline TOC.

<u>CVCC battalion TOC</u>. The automated (CVCC) TOC contained four automated workstations and a large-screen Situation and Planning Display (SitDisplay), located in an M577 extension. The four workstations were configured for the battalion commander/XO, the assistant S3, the S2, and the FSO. An additional workstation (CSS) was located in the exercise control room (ECR) for scenario control purposes. The workstations exchanged data on a TOC local area network (LAN), connected to the CVCC network.

[5]The Bde O&I network was allocated to a citizens band channel due to a shortage of stand alone SINCGARS radio simulators.

[6]The battalion O&I net was established to handle routine information without cluttering or interfering with the battalion command net (Department of the Army, 1988c), and for fire support and admin/log traffic, since neither net was represented.

Each TOC workstation consisted of two color monitors, a keyboard, a mouse, and a central processing unit (see Figure 5). The left-hand monitor was configured as a map display, which portrayed a digital topographical map. Pull-down menus on the map display enabled the operator to create, edit, and transmit overlays on the battalion digital net. Other menus allowed the operator to copy overlays from other workstations on the LAN. The right-hand monitor, called the Communication and Planning Display, presented textual information received from other sources. It enabled the user to create, edit, store, and transmit reports generated from his workstation, and to access reports from other workstations on the LAN. See Leibrecht et al. (in preparation) for a more detailed description of TOC workstation capabilities.

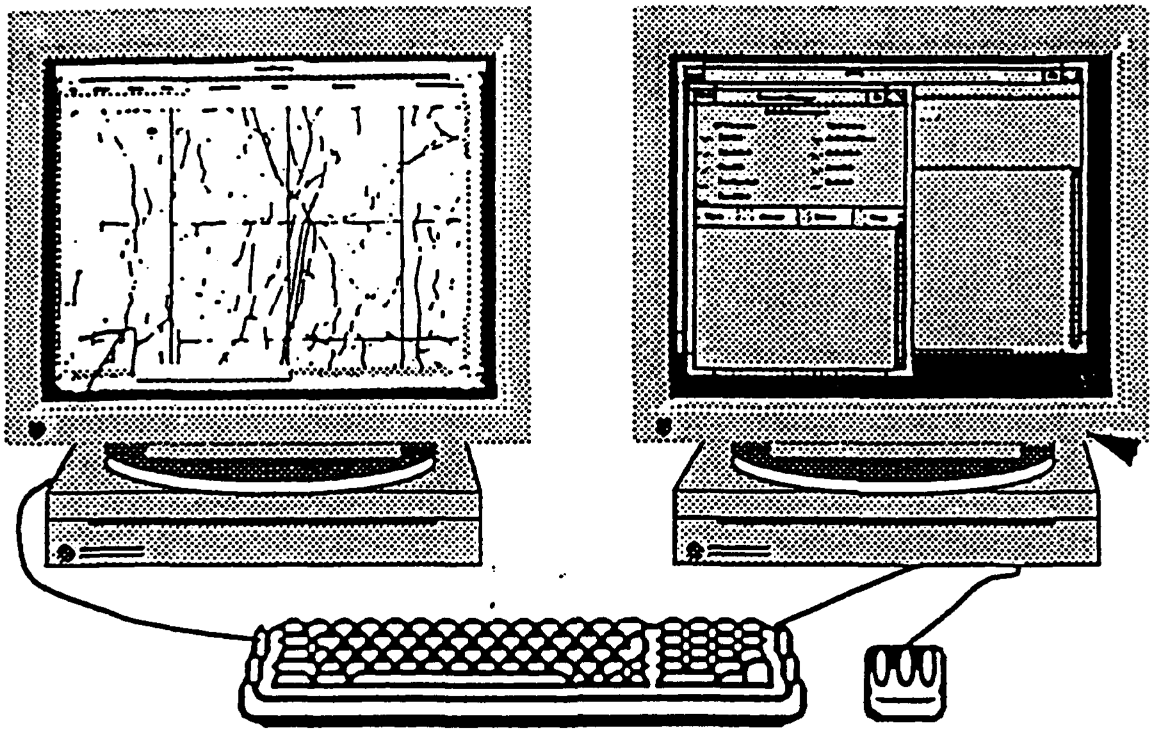

Figure 5. CVCC battalion TOC workstation.

The CSS workstation included all the capabilities of the other workstations, and allowed control personnel to monitor message traffic and unit locations in the same format as the participants and the TOC staff. The CSS workstation also contained specialized utilities for exercise control that are detailed in Leibrecht et al. (in preparation).

<u>SAFOR and MCC controlled forces</u>

As previously explained, the majority of the battalion consisted of SAFOR. The friendly SAFOR were controlled through two workstations located in the ECR. A third workstation served

as the OPFOR terminal. The battalion's organic heavy mortar platoon and direct support artillery were generated through the MCC system. The following paragraphs outline how these forces were controlled.

SAFOR. SAFOR units could be controlled "on-line" to accomplish specific tasks, or programmed to execute more comprehensive combat missions. Maximum engagement ranges, gunnery proficiency levels, initial positions, and routes to be followed in offensive operations were programmed and stored. The OPFOR operated entirely from exercise files for each training and test stage, in order to expose each test unit to the same threat. Friendly SAFOR exercise files placed SAFOR vehicles in their initial positions for each stage, and included a copy of the standard overlay for that stage. The actual movement between positions was left to the operator based on the unit commander's direction.

In the Baseline condition, friendly SAFOR operators communicated with the simulator-mounted unit commanders and TOC staff using voice radio only. Strict exercise control procedures limited the type and timing of information that the SAFOR operator and the radio operator passed to the participants (see "Exercise Control Procedures," later in this report). Operational messages (CONTACT, SPOT, situation report or SITREP and other reports) appeared on the SAFOR workstation screen to represent reports from units controlled through that workstation. These text messages were then relayed by voice to the commander in the simulator. If the pace of the operation did not permit the SAFOR or radio operator to send all the reports, the operator sent the most critical reports (SPOT, CONTACT, current status) according to established contingency rules.[7] SAFOR operators also received orders and FRAGOs verbally, and then implemented those orders using the SAFOR workstation.

In the CVCC condition, friendly SAFOR vehicle locations and status were automatically reported to the CVCC digital network, to provide position icons and logistics status on the CCDs and TOC workstations. Furthermore, digital CVCC messages were automatically generated by the SAFOR[8] and transmitted on the digital network at the same time that the corresponding text message was displayed on the SAFOR operator's workstation. Voice radio augmented the digital communications, and allowed the SAFOR or radio operator to interact with the commanders in simulators.

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[7]A copy of SAFOR operator guidelines and contingency rules are included in Leibrecht et al., 1993.

[8]SAFOR could create CONTACT, SPOT, SHELL, and SITREP, but not INTEL, CFF, ADJUST, or NBC reports. SAFOR-generated SITREPs were incomplete, lacking a front-line trace and commander's intent.

However, there was no capability for SAFOR operators to receive digital messages from their unit commanders.

MCC forces. The MCC-generated mortar and artillery assets were initialized by the Battle Master at the start of the exercise. The FSO executed indirect fires and moved the mortar platoon using the FSE terminal in the TOC. The howitzer batteries were moved by the Battle Master, at predetermined times during the scenario. Fire support units would not accept fire missions during movement, but a unit could be halted in position at any time during the move. Once halted, each unit took several minutes to set up before it could resume firing.

The only difference in fire support operations between conditions lay in the tools that the FSO had to monitor the battle and receive CFFs. The Baseline FSO received only voice radio calls, while the CVCC FSO received mainly digital calls on the FSO workstation. However, there was no automated link between the CVCC TOC workstation and FSE terminal. All voice and digital indirect fire requests had to be manually entered in the FSE terminal. Likewise, no capability existed to provide POSNAV icons for MCC-generated forces. Therefore, neither the mortars nor the howitzers were automatically posted on TOC workstations or CCDs.

Procedures

This subsection outlines the procedures used to prepare participants for the test scenario, provides an overview of the scenario, explains exercise control procedures, and outlines data collection procedures. A copy of the weekly training and test schedule may be found in Leibrecht et al. (in preparation).

Training Program

The training program was executed during the first three days of each test week. Table 12 summarizes the program. Program objectives were to provide participants training on the basic simulator (in both CVCC and Baseline conditions), the CVCC system (CVCC condition only), and on company and battalion operations. With respect to unit operations, the general training objectives were to: (a) provide practice moving and fighting as a unit in the SIMNET environment, (b) exercise the battalion SOP, (c) provide "team-building" opportunities between the participants, TOC staff, and SAFOR operators, and (d) rehearse tactical tasks required within the test scenario. Training was progressive, beginning with individual tasks on Monday and Tuesday morning. Collective training began at the crew level during the latter half of Tuesday morning. Company level training occurred on Tuesday afternoon, followed by battalion level training on Wednesday. Selected training materials from the individual training program may be found in the support package for the battalion evaluation (Sawyer et al., in preparation).

Table 12

Training Program Characteristics

Progressive (crawl, walk, run) --
o Individual to crew to company to battalion level
o Basic simulator to CVCC
Tailored --
o By crew position -- emphasis on TC tasks
o By condition
o Emphasis on navigation in Baseline
o Emphasis on CCD, CITV in CVCC

Individual training. The individual training program began with the General Introduction on Monday morning, then proceeded to a program that was tailored by condition and crew position. For CVCC crews, the tailored program focused on operating the CVCC equipment. For Baseline crews, the tailored program reinforced SIMNET navigation, in order to reduce the impact of the SIMNET environment on any data related to navigation performance. Figure 6 is a graphic representation of the individual training program.

The General Introduction included an overview of the battalion evaluation, and general rules of conduct within the MWTB and the evaluation. Participants completed Privacy Act statements and biographical questionnaires (copies of which may be found in Leibrecht et al., 1993) at the end of the introduction.

Given that the primary focus of the battalion evaluation was on C^2 issues, and that all officers filled leadership positions at either the company or battalion echelon, the bulk of the individual training program was dedicated to their training at the vehicle commander's position.[9] The two thrusts within vehicle commanders' training were: (a) to ensure a common knowledge level on basic tank simulator functions, and (b) to cover equipment-specific requirements of that week's test condition.

Vehicle commanders' training began, in both conditions, with a classroom presentation that addressed the differences between

[9]The term, vehicle commander, is used throughout this report to refer to the crew position in the simulator as well as the entire sample population of officers.

Period	CVCC		Baseline	
	Officers	Gunners & Drivers	Officers	Gunners & Drivers
Mon-AM	General Introduction		General Introduction	
	Tank v. Sim	Excused	Tank v. Sim	Excused
	CCD Demonstration		SIMNET Navigation Briefing	
	Seat-specific training		Seat-specific training	
	CCD Hands-on Training		TC's Navigation Exercise	
Mon-PM			Excused	
	CCD Skills Test			
	CITV Briefing CITV Hands-on Training			
Tues-AM	CITV Skills Test			
	SAFOR Briefing Bn SOP Briefing	Seat-specific training	SAFOR Briefing Bn SOP Briefing	Seat-specific training

Figure 6. Individual training program.

the M1 simulators used in the evaluation and an actual M1 or M1A1 tank. This period had several objectives: (a) to highlight features unique to the simulator, (b) to explain implications of the simulation environment relevant to combat operations, and (c) to alert participants to common problems that crews experience within the simulation.

For Baseline units only, the tank versus simulator briefing was immediately followed with a SIMNET navigation briefing. The first objective of the navigation training was to point out the special navigation tools built into the simulator. The second objective was to reinforce basic land navigation techniques, with emphasis on how those techniques were to be employed in SIMNET.

In the CVCC condition, the tank versus simulator briefing was followed by a "CCD demonstration." The briefer demonstrated CCD operation using a large screen display.

The next training event for both CVCC and Baseline groups was the vehicle commander's seat-specific training. This was the first hands-on training phase, and trained officers on basic M1 simulator operations. Participants operated all primary commander's controls, with specific emphasis on those that are unique to the simulator. They also became familiar with gunner's and drivers controls.

For Baseline units only, the first day of training concluded with a hands-on, SIMNET navigation exercise. Officers were paired together as vehicle commander and driver and were required to navigate their vehicles through a series of checkpoints on the SIMNET terrain. Each officer was given the six-digit grid location of his start point, a mapboard with overlay, and a protractor. After the first vehicle commander successfully navigated to three checkpoints, he traded positions with his cohort. Control personnel monitored progress using a plan view display (PVD), and communicated with the crews by voice radio. The controller ensured that each officer navigated to within approximately two hundred meters of each checkpoint. The navigation training exercise concluded at the lunch hour on Monday.

In CVCC units, the training continued with CCD hands-on training. Officers learned how to accomplish all CCD functions, and practiced CCD tasks repeatedly in order to gain proficiency. Trainers explained each function, talked participants through the function, then observed while the participant practiced the task. The CCD training concluded with a skills test that verified the TC's ability to use the equipment. CCD training began before lunch on Monday, and concluded about halfway through the afternoon.

In the CVCC condition, the remainder of Monday afternoon was dedicated to CITV training. This period began with a classroom presentation on the CITV. TCs then proceeded to the simulators for hands-on training. The same training approach was used for the CITV as was used for CCD training. Trainers administered a CITV skills test on Tuesday morning to verify learning.

The common training program on Tuesday began in the classroom with a briefing on SAFOR operations. This briefing, conducted normally by the senior SAFOR operator, explained the capabilities and limitations of the forces that participants would command and control during the evaluation. The briefer explained how unit commanders would communicate with SAFOR operators, how and under what conditions the SAFOR would report, as well as what the SAFOR could and could not do.

The last officers' training session on Tuesday was a briefing on the unit SOP.[10] The Battle Master distributed copies of the battalion SOP extract to all officers, and explained some of its key points. The Battle Master emphasized the voice network structure and the expected division of labor between company commanders and XOs regarding message processing.

Individual training for gunners and drivers was also tailored to their crew position. Gunners and drivers were

[10]A copy of the battalion SOP may be found in Sawyer et al. (in preparation).

excused following the general introduction on Monday morning, and told to return at a specified time on Tuesday morning for seat specific training. They were familiarized with the other positions in the simulator, and received detailed, hands-on training in their assigned positions.

During CVCC test weeks, the time period following the battalion situational training exercise (STX) on Wednesday morning was dedicated to CCD reinforcement training for officers only. Training began with a short lecture using the large-screen display, then vehicle commanders returned to the simulators for a hands-on message processing exercise. The exercise was designed to reinforce CCD training between battalion level training exercises.

The lunch hour on Wednesday was used to discuss selected research issues with officers. A representative of the ARI-Fort Knox Field Unit led the discussion. Participants were briefed on the use of kill suppress and its implications for the results of the evaluation.[11] The discussion also focused on the need for participants to navigate for themselves rather than following SAFOR elements between fighting positions.

Collective Training. Collective began at mid-morning on Tuesdays, and lasted through Wednesday afternoon of a test week. Training progressed in crawl-walk-run fashion through four distinct exercises: crew "sandbox" training, a company STX, a battalion STX, and a battalion training exercise. During Baseline training, navigation refresher training for all crews occurred between the battalion STX and the battalion training exercise. The remainder of this section describes the collective training program in greater detail. Table 13 summarizes the collective training program.

Each collective training event was preceded by an inbriefing, and closed with a group debriefing. Battalion and company OPORDs existed for each tactical scenario in order to simplify participants' planning and to standardize execution. The OPORDs were issued at the start of the exercise. Participants were given time to review the orders, to coordinate with the TOC staff and each other, and to refine their plans. Crews were allocated fifteen minutes to conduct simulators checks prior to actual scenario execution.

In crew "sandbox" training, each crew was required to negotiate a series of checkpoints positioned in a twenty-five square-kilometer area (i.e., 5 Km X 5 Km). In addition to

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[11]Kill suppress rendered manned vehicles invulnerable within the simulation, in order to keep unit commanders intact throughout the data collection period. Leibrecht et al. (in preparation) explains kill suppress and its implications in greater detail.

Table 13

Collective Training Program Highlights

Crew sandbox training

- Individual crews
- Cross-country navigation
- Friendly and enemy SAFOR
- Location, enemy action, own status reporting requirements

Company situational training exercise

- 4 tank companies: 3 manned, 1 SAFOR
- Battalion OPORDs and FRAGOs, Company OPORDs
- Companies delay on line
- Companies counterattack on line
- Battalion Commander and S3 observe/CPX battle
- Company Commanders learn to employ SAFOR platoons
- Exercise Battalion SOP
- Limited Brigade and adjacent unit radio traffic

Battalion situational training exercise

- Full Battalion structure
- Battalion and Company OPORDs
- Companies defend from mutually supporting BPs
- Battalion Command Group employs manned & SAFOR companies & SAFOR scout platoon
- Limited Brigade and adjacent unit radio traffic

Navigation refresher training (Baseline only)

- Crew level refresher training
- Modified version of crew sandbox exercise

Battalion training scenario

- Full Battalion structure
- Brigade, Battalion and Company OPORDs, Brigade and Battalion FRAGOs
- Stealth-based terrain recon
- Companies delay from mutually supporting BPs
- Battalion counterattacks with 3 Companies on line
- Representative Brigade and adjacent unit traffic

navigating, crews sent tactical reports and engaged semiautomated OPFOR vehicles. Each sandbox also contained BLUFOR vehicles to reinforce vehicle identification. In the CVCC condition, crews were encouraged to use the CCD's navigation component and digital reports to meet the training objectives.

The company STX, scheduled for Tuesday afternoon, exercised C^3 and reporting requirements in a delay scenario. In this exercise, the four line companies operated on line, each in a separate lane. Each company delayed against and OPFOR motorized rifle battalion, reinforced (MRB+) in Stage 1, then attacked an OPFOR motorized rifle platoon (MRP), reinforced with one or two tanks in Stage 2. During this exercise, the Battle Master

assumed the role of battalion commander. Communications with the notional brigade headquarters and adjacent units were held to a minimum in order to focus on communications between the battalion TOC, the company command groups, and the SAFOR operators.

During the company STX, the battalion commander and S3 received concurrent training in the TOC, as a team building activity. In the CVCC condition, this training also included an introduction to the TOC's automated capabilities. As the tactical situation developed, the battalion commander's and S3's crews followed one of the companies, and reinforced that company's fires. During the second stage, the battalion commander and S3 mounted their simulators to observe the battle.

The TOC staff participated in the company STX to receive and relay tactical reports, and to become familiar with the participants' operational preferences. The TOC staff also enforced reporting standards as outlined in the battalion SOP.

The battalion STX was scheduled for Wednesday morning. A, B, and C Companies established battle positions around an engagement area, and D Company (all-SAFOR) established a position in depth. In addition to the four line companies, the battalion STX incorporated the entire battalion command structure, a SAFOR scout platoon, and more extensive communications with the brigade and adjacent forces. The OPFOR represented a motorized rifle regiment (MRR) attacking with two MRBs+ in the first echelon. A MRP, acting as a combat reconnaissance patrol (CRP), preceded each lead echelon MRB+. As the attack continued in depth, the OPFOR became vulnerable to counterattack. The battalion commander was expected to identify the opportunity and execute an appropriate counterattack plan.

The navigation refresher training was scheduled for the last hour on Wednesday morning during Baseline weeks. This crew level exercise was essentially a repeat of the crew sandbox training, with its primary emphasis on navigation tasks. Each crew was assigned the same sandbox as they had operated in on Tuesday. The requirement varied from Tuesday in that simulators were placed at the last checkpoint in the sandbox, and crews were to negotiate the checkpoints in reverse sequence.

The battalion training scenario, scheduled for Wednesday afternoon, served as a "dress rehearsal" for the test scenario. Unit commanders participated in a terrain reconnaissance along the battalion's front line as part of the preparation for the tactical scenario. A, B, and C Companies established initial delay positions on line, with D Company in depth. In stage one, BLUFOR companies delayed the two lead echelon MRBs+ of an attacking MRR. As the situation developed, D Company was to counterattack remnants of the lead echelon MRBs+, and complete their destruction. During the conduct of the delay, the brigade commander ordered a battalion level counterattack to intercept the second echelon MRB+ in a designated engagement area. In

stage two, D Company anchored the counterattack while A, B, and C Companies maneuvered to flank the OPFOR's second echelon MRB+. An OPFOR chemical attack was simulated against the BLUFOR during stage two to prompt an NBC-1 report.

Scenario Overview

The test scenario was scheduled for Thursday of each week. The scenario was divided into three tactical stages, preceded by a preparation period. The divisions of the test scenario are referred to as stages in order to avoid confusion with the tactical phases described in OPORDs 20 and 200 (see Appendix C). Stages and phases did not correspond with each other. The scenario began with an inbriefing by the Battle Master. After the inbriefing, the Battle Master published the Brigade OPORD, then turned the participants over to the battalion XO for the battalion OPORD. Preparation continued with a terrain reconnaissance and internal coordination, and culminated with simulator pre-operations checks. Table 14 summarizes the sequence of events in the test scenario.

The tactical situation leading up to the test scenario involved a defensive operation to the battalion's front. In that operation, forward units stopped the lead divisions in an OPFOR combined arms army, but were forced to withdraw when the OPFOR's second echelon force was committed. The test unit's mission was to assist the disengagement and rearward passage of the friendly force, then conduct an aggressive delay in sector for four hours, and destroy the lead echelon MRR of a motorized rifle division (MRD).

The delay scenario was initiated at __0950R ___ 9_. 1-10 Armor was set with A, B, & C Companies in battle positions (BPs) along Phase Line (PL) KING, oriented to the South. D Company was in reserve along PL CLUB. The battle handover had been effected, and the last elements of TF 1-2, 1st BDE, 52nd ID (M) had completed their passage of lines through 1-10 Armor's FLOT, but were still in the 1-10 Armor sector. The battalion scout platoon, after assisting the passage of lines, moved forward to establish initial contact with the advancing OPFOR. The scouts reported OPFOR recon elements, and Division intelligence reported OPFOR activity forward of PL KING. The Scouts pulled back, completed their passage of lines, and moved back to consolidate along PL JACK.

Stage 1: DELAY. Stage One was the initial delay. The OPFOR first echelon MRR attacked with two MRBs+ abreast (see Figure 7). As the BLUFOR delayed in sector, the brigade located the second echelon MRB+ of the lead echelon MRR, and ordered the test unit to counterattack.

As this stage began, two OPFOR recon platoons advanced to locate 1-10 Armor's initial defensive position. The scout platoon consolidated and moved to screen the battalion's left

Table 14

Test Scenario Sequence

Preparation

- Bde OPORD briefing
- Bn OPORD briefing
- Leaders' recon
- Planning and coordination
- Pre-exercise message traffic
- Simulator pre-ops checks

Stage 1 -- Delay

- Test unit engages, damages 2 OPFOR MRBs
- Bde counterattack FRAGO received and processed
- Remnants of OPFOR lead echelon MRBs stop, establish hasty defenses
- Test unit consolidates in subsequent BPs

Stage 2 -- Counterattack

- TOC publishes FRAGO
- Test unit attacks through remnants of Stage 1 OPFOR (1 MRC)
- Bde FRAGO to resume delay received and processed.
- Test unit engages, destroys 2nd echelon MRB of OPFOR lead echelon regiment, consolidates on OBJ.

Stage 3 -- Delay

- TOC publishes FRAGO
- Cos reposition to resume delay
- Test unit engages 2 OPFOR MRBs
- OPFOR employs chemicals
- BLUFOR submits NBC-1, withdraws to subsequent BPs and consolidates

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flank. The OPFOR executed a ten minute artillery barrage along PL KING. The OPFOR recon platoons established contact with A and C Companies. Subsequently, the OPFOR attacked with two MRBs+ in the first echelon of the 144th MRR and one MRB+ in its second echelon. Each MRB+ had two motorized rifle companies, reinforced (MRCs+) in its first echelon and a third MRC+ in its second echelon. Meanwhile, a friendly tank company from TF 1-2 continued its rearward movement (North) past D Company.

As the battle progressed, A Company was forced to delay because of the OPFOR pressure and because 1-92 MECH on the West (right) of 1-10 Armor had begun to delay. The battalion CDR

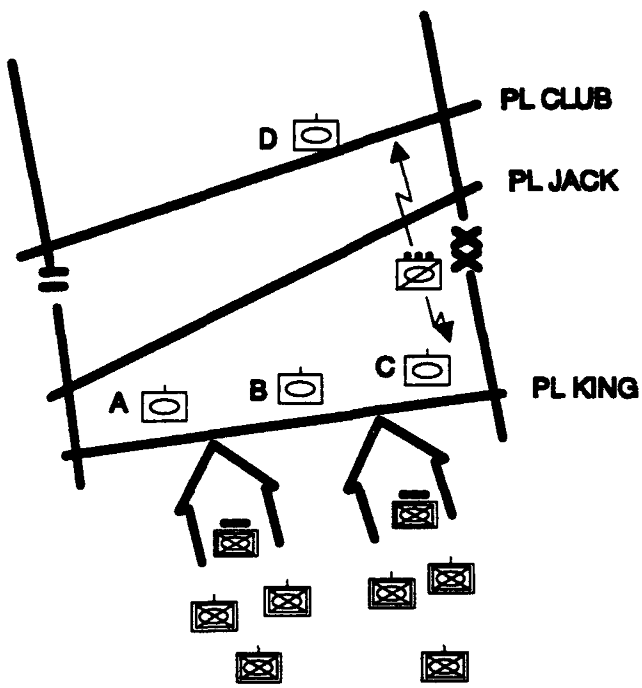

Figure 7. Test scenario situation: Stage 1.

ordered the battalion to delay to subsequent BPs. After the movement to the subsequent BPs was initiated, Brigade issued FRAGO 1 to OPORD 20. The FRAGO required 1-10 Armor to counterattack South West to destroy the 144th MRR's second echelon MRB+. The battalion commander sent a warning order and the staff began preparing battalion FRAGO 1.

As the situation developed, Brigade granted permission for 1-10 Armor to commit its reserve (D Company) in a limited counterattack. As C Company (in the East) delayed, the easternmost OPFOR MRB+ turned to the North West and broke contact with C Company. Shortly thereafter, B Company reported that the OPFOR had broken contact and turned toward A Company. Meanwhile, A Company remained in contact as it delayed to PL Club. D Company was committed to relieve the pressure on A Company. Throughout the battle the OPFOR movement, reports from BDE, and reports from 1-92 MECH built the situation that the main OPFOR effort was to the North West. As the stage ended, the first echelon MRBs of the 144th MRR had either been rendered combat ineffective or passed through the 1-10 Armor sector to the North West. All companies were set in BPs generally along PL Club in the West, and PL Jack in the East, and were preparing to counterattack. The battalion staff was ready to publish battalion FRAGO 1.

<u>Stage 2. COUNTERATTACK</u>. The counterattack was executed in the second stage of the scenario, against an OPFOR MRB+.

Starting positions for each unit corresponded with the scripted end-stage positions from Stage One. Figure 8 shows the disposition of the Battalion as it approached the LD, approximately 12-15 minutes into Stage Two. With the counterattack in progress, division intelligence assets located the enemy's second echelon MRR. This led to a second Brigade FRAGO requiring the battalion to resume the delay (i.e., in Stage 3).

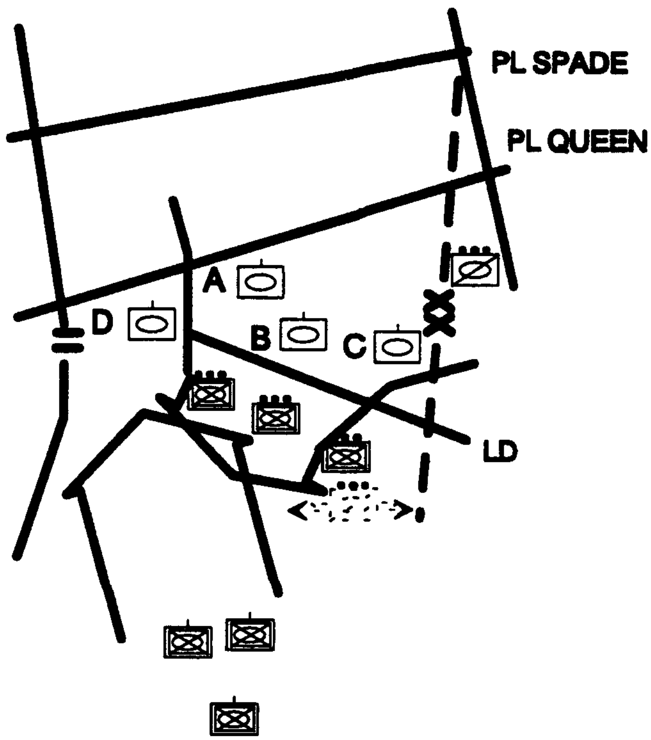

Figure 8. Test scenario situation: Stage 2.

As this stage began, the TOC issued FRAGO 1 to OPORD 200 (via voice radio in baseline and via digital transmission in CVCC). D Company remained in its defensive position along PL Club. The remainder of the battalion attacked with three companies abreast: A Company right (West), B Company in the center, and C Company on the left (East). The scout platoon screened the battalion left flank between C Company and the adjacent unit.

After the companies crossed the LD, Brigade issued FRAGO 2 to OPORD 20, to resume the delay upon completion of the counterattack. The battalion commander sent a warning order and the staff started preparing battalion FRAGO 2. As the counterattack progressed, the battalion encountered remnants of the OPFOR lead echelon in hasty defenses. These elements were destroyed and overrun. As the battalion reached its objective, it made contact with the 2nd echelon MRB+ of the 144th MRR (with two MRCs+ in its first echelon and one MRC+ in its second

echelon), and engaged the OPFOR. As this stage ended, the OPFOR was eliminated, A, B, C Companies were on their objectives, and D Company remained in its supporting position in depth. The battalion staff was prepared to publish battalion FRAGO 2.

Stage 3: DELAY. In Stage Three, the test unit resumed the delay against the two lead echelon MRBs+ of the second echelon regiment. The stage began with BLUFOR units on their Stage Two objectives. Figure 9 represents their disposition after repositioning for the delay, approximately 10-15 minutes into Stage Three. In this stage, the OPFOR supported its attack with non-persistent chemical munitions. The scenario ended as the test unit relayed the NBC-1 reports and established its subsequent battle positions.

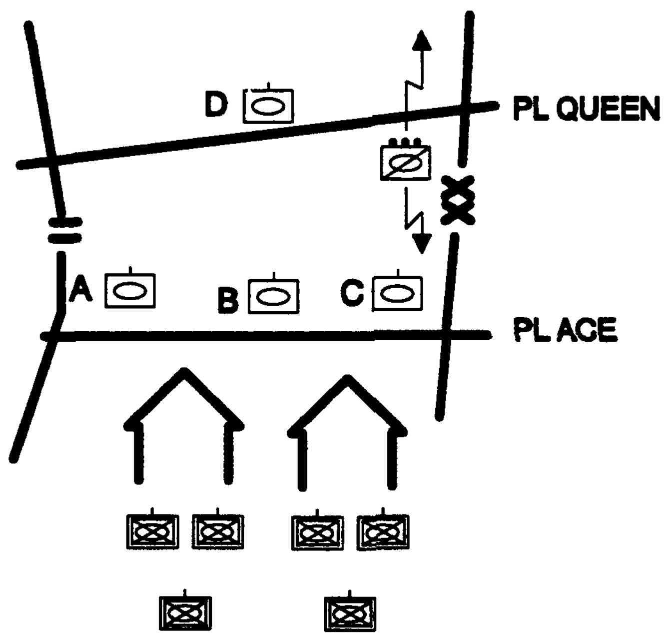

Figure 9. Test scenario situation: Stage 3.

This stage began when the TOC issued FRAGO 2 to OPORD 200 (via voice radio in baseline and via digital transmission in CVCC). FRAGO 2 established new BPs along PL ACE (per Bde FRAGO 2). A, B, & C Companies moved to establish defensive positions from West to East, respectively. D Company moved to the center of sector along PL Queen, as the battalion reserve. The OPFOR represented the two lead MRBs+ of the 146th MRR, a second echelon MRR of the 39th GMRD. Each of the MRBs+ attacked with two MRCs+ in its first echelon and one MRC+ in its second echelon. The OPFOR introduced non-persistent chemical munitions to penetrate the BLUFOR lines. 1-10 Armor delayed to subsequent BPs along PL Queen. As this stage ended, the companies were set in position, had submitted SITREPs, and were prepared to continue the delay mission.

Exercise Control Procedures

Each training and test scenario was executed according to established control procedures (see Leibrecht et al., 1993) to maintain consistency across conditions and test weeks. The battalion TOC staff assisted the battalion commander by preparing tactical overlays, synthesizing critical battlefield information, and maintaining a broad picture of the entire battlefield. Exercise participants were permitted to conduct pre-mission planning and coordination in the TOC, but they were not allowed in the TOC during the exercises. This prohibition was explained within the scenario context by the pace of the battle and the distance to the TOC. A "Scenario Situation and Events List" outlined the procedure for each individual scenario. The events list was used by the ECR staff to coordinate actions within the simulation. Copies of the events list may be found in Sawyer et al. (in preparation).

Two types of documents laid out SOPs for control personnel, to ensure consistent implementation of training and test exercises (see Leibrecht et al., 1993). The first type included operating guidelines for the ECR and TOC staff. The second type of exercise control document specified the decision process and options for handling various contingencies. Both the guidelines and contingency documents were generic to all scenarios, whereas the events lists were specific to each scenario.

Operating guidelines. Within the ECR, "SAFOR Operator Radio Protocols" established the rules for operator-generated reports and responses on the voice radio network. SAFOR operators' responsibilities to the battalion and company commanders had to be carefully balanced with their responsibilities as control staff members. SAFOR controllers executed the orders given them by the unit commanders, but strict controls existed for certain actions. A copy of the SAFOR operator radio protocols may be found in Sawyer et al. (in preparation).

With respect to reporting, the radio protocols specified when and what information could be reported. Because each SAFOR operator controlled up to seven BLUFOR platoons, he had immediate, direct access to more tactical information than any individual platoon leader would have. For the CVCC condition, digital CONTACT, SPOT, SHELL, and SITUATION reports were generated automatically by the SAFOR elements, based on reporting software subroutines. In the Baseline condition, the same reports were displayed on the SAFOR message screen. In order to ensure consistency between conditions, the SAFOR and radio operators waited until the message appeared on the screen to transmit the voice report in the Baseline condition. In both conditions, certain events could be reported as soon as the SAFOR operator observed them, but the information transmitted was very brief and non-specific. For example, if the operator observed a given platoon engaging an OPFOR element, he was to report "ENGAGING TANKS AND B-M-Ps, REPORT TO FOLLOW." Also, because of

their familiarity with the scenarios, SAFOR operators knew when and where the OPFOR would appear, and knew the content of FRAGOs. However, they were forbidden from sharing that information with the participants. Moreover, when the FRAGOs were issued in the course of the scenario, the SAFOR operators had to avoid filling in missing information from their experience.

With respect to SAFOR positioning and movement, operators usually did as they were ordered by participants without question. However, there were some circumstances that were not permitted. For example, if a unit commander directed a SAFOR platoon to move beyond the FLOT prior to enemy contact in a defensive situation, the Battle Master intervened as the Brigade Commander to disallow the maneuver. Any such intervention was handled with a relevant tactical reason.

A "TOC SOP" was integrated in the Battalion SOP Extract, to establish general TOC operating guidelines. A control staff only addendum to the TOC SOP established specific guidelines regarding TOC staff-participant interaction (Sawyer et al., in preparation). The battalion XO supervised TOC staff activities. He monitored and directed the staff to ensure consistent application of the rules. Operating rules were practiced during staff training sessions and carefully followed during all test week training and testing activities.

As with the SAFOR operators, the TOC staff also had to balance responsiveness to the battalion commander with exercise control responsibilities. Standardization was accomplished through the battalion OPORDs and FRAGOs, and through scripts used during the orders briefing and the leaders' reconnaissance. Also, as with the SAFOR operators, the TOC staff avoided previewing tactical information based on prior knowledge of training and test scenarios. Any information provided to the command group from the TOC during the course of the scenario was consistent only with the information that the TOC staff received up to that point. When the brigade FRAGO was released during stages 1 and 2, the TOC staff worked strictly within the current tactical situation and the battalion commander's guidance. If asked for recommendations, the TOC tailored any suggestions to the progress of the fight up to that point in time. As a result, the battalion FRAGOs that were developed "on line" typically varied between test groups. At the start of the subsequent stage, the TOC staff published the standardized FRAGO for the stage (see Appendix C) in lieu of the one that was developed "on line," in order to restore standardization between test groups.

Contingency rules. Contingency rules addressed cases involving participant absences, research staff absences, interaction between participants and research staff, equipment breakdowns, and schedule delays. The contingency rules helped to ensure that personnel and technical problems were handled in a consistent manner across test weeks. Any significant departures from established control procedures (as might be necessitated by

equipment problems) or contingency rules were noted in writing and later reviewed by the research staff for impact on the data collected. Where necessary, data reduction or analysis was adjusted to account for departures from planned procedures. Leibrecht et al. (in preparation) provide a more extensive description of the contingency rules.

Data Collection Procedures

Data were collected through a variety of means. On-line data collection was accomplished through automated and manual means. Automated data collection was accomplished using the MWTB DataLogger. On-line manual data collection included logs maintained by various control personnel. The respondents were also asked to provide feedback after the fact through the exercise debriefing and questionnaires. Post-hoc data collection included transcriptions of radio transmissions from the DataLogger files of test scenarios. A more detailed description of data collection instruments and procedures may be found in Leibrecht et al. (1993).

The data were grouped into a series of measures that were designed to support the issues identified earlier in this report. Those issues were further defined from functions supporting four of the seven tactical BOSs. Appendix D contains a complete list of measures, categorized by BOS and functions. Table 15 recaps those BOS functions. The remainder of this subsection will outline the kinds of measures used to compare unit performance of Baseline and CVCC battalions.

Command and Control BOS. Six functions served as the basis for measures of performance in the Command and Control BOS, as shown in Table 15. Measures used to support the first three functions included the time necessary to transmit FRAGOs, enemy, and friendly information, and the duration of clarifying transmissions. In the Baseline condition, transmissions were also scored for consistency of relayed information. In the CVCC condition, perfect information consistency was assumed for all digital messages. SITREPs were scored for accuracy of reported locations. Linear control measure crossings and the arrival at point or area control measures (i.e., checkpoints and battle positions) were scored also for latency. One measure recorded the time required to compile and relay fuel and ammunition status on request from higher headquarters. These measures involved a combination of data collected on-line by both automated means and control logs, and data that were reduced manually from scenario playbacks.

Data for the function, "manage means of communicating information," measured the duration and number of radio transmissions, to determine whether the availability of digital communication would reduce a unit's voice radio signature. These data were collected and analyzed by automated means.

Table 15

Selected BOS Functions

Command & Control BOS	Maneuver BOS
o Receive & transmit mission	o Move on surface
o Receive & transmit enemy information	o Navigate
o Receive & transmit friendly troop information	o Process direct fire targets
o Manage means of communicating information	o Engage direct fire targets
o Assess situation	o Control terrain
o Direct & lead subordinate forces	
	Fire Support BOS
	o Process ground targets
	Intelligence BOS
	o Collect threat information

Participants' assessments of the tactical situation were measured through a questionnaire that was completed immediately following the last stage of the test scenario. The data provided by the participants were compared to corresponding data from DataLogger to analyze participants' responses for accuracy.

Data for the function, "direct and lead subordinate forces" assessed whether the battalion prevented decisive engagement and withdrew intact in delay situations, whether the battalion massed fires effectively on the OPFOR in the counterattack, and whether the battalion met the commander's intent. These evaluations were made by the Battle Master's on-line observation, based on objective criteria extracted from the battalion task force mission training plan (Department of the Army, 1988a).

Maneuver BOS. Measures of performance supporting the maneuver BOS were based on the following functions: (a) move on surface; (b) navigate; (c) process direct fire targets; (d) engage direct fire targets; and (e) control terrain.

The first two functions were concerned with tactical movement. The first, "move on surface," considered the positioning and movement of platoons and companies. Specific measures investigated the stand-off that the unit maintained from the enemy force, and the BLUFOR's exposure to enemy observation. In delay situations, the range to the opposing force when a unit displaced was of interest. In the counterattack, times required to reach the LD and objectives were recorded. These data were extracted by the automated data processing equipment, based on

"flags[12]" recorded by control personnel when specific events occurred.

Individual vehicle movement data were analyzed under the second maneuver BOS function, "navigate." Measures for this function quantified distance travelled, fuel usage, and the time to complete each scenario stage. These data were extracted by the automated data processing system. Control personnel also flagged and noted when any participant's vehicle wandered out of its assigned sector, or otherwise appeared misoriented. In addition to the automated data generated on misoriented vehicles, the Battle Master encouraged the participants to discuss lost vehicle incidents in scenario debriefings.

Direct fire target acquisition among manned simulators was analyzed under the function, "process direct fire targets." Since DataLogger recorded lasing events, the first lase from a manned vehicle to any target was used as an indication that the crew had acquired that target. Data processing routines determined times to acquire targets (i.e., the elapsed time from target exposure to first lase), lase to fire times (i.e., the elapsed time from the first lase on a target until the crew engaged that target), elapsed times between first lases on different targets, and maximum ranges. Control personnel noted and flagged any observed fratricide incidents. These events were discussed in debriefings, and captured in DataLogger files.

Direct fire effectiveness among both manned vehicles and SAFOR was analyzed under the function, "engage direct fire targets." Measures supporting this function included the percent of OPFOR and BLUFOR killed in each stage, loss:kill ratios, mean hit and kill ranges, and the relative location of OPFOR losses in delay stages (i.e., the number of enemy losses beyond designated phase lines). Additional measures that quantified only the performance of manned vehicles reported the percent of OPFOR vehicles killed by manned vehicles, the number of rounds fired, hits per round fired, kills per hit, and kills per round fired. The automated data processing system also reported the number of hits scored against each manned vehicle that would have killed that vehicle if kill suppress had not been used.

The degree to which the friendly force controlled terrain was determined using measures that reported the number of OPFOR vehicles that crossed designated phase lines in each tactical stage, and the Battle Master's assessment whether the BLUFOR was bypassed by the OPFOR in delay stages. Automated data processing

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[12] Event flagging is a utility on the PVD that allowed the control staff to augment the DataLogger record with electronic indices. In addition, the Asst S3 in the TOC flagged selected reports using a personal computer that was connected to the Ethernet. See Leibrecht et al. (1993).

routines determined whether any OPFOR vehicles penetrated those phase lines.

Fire Support BOS. Measures of performance supporting the function, "process ground targets," quantified the positional and descriptive accuracy of calls for fire (CFFs). Automated data processing routines determined the distance between a reported grid and the actual grid for an OPFOR element at the time a CFF was sent on the battalion net. Descriptive accuracy determined whether the type of target reported was present. These data were not adjusted for any expected processing time on the part of the supporting indirect fire units. Since the delays associated with processing CFFs were out of the participants' control, participants were encouraged to report actual locations, and the FSO was responsible for "leading" moving targets.

Intelligence BOS. Measures of performance supporting the function, "collect threat information," quantified the positional accuracy of SPOT, SHELL, and CONTACT reports, and the descriptive accuracy of SPOT and CONTACT reports.

Support Staff

The test support staff was responsible for training exercise participants, controlling all scenarios and exercises, operating the ECR stations, and operating the surrogate battalion TOC. Figure 10 shows the support staff structure during test scenario execution. This staff also administered manual data collection instruments.

Scenario Roles and Responsibilities

The Exercise Director retained overall decision-making authority for all matters regarding the conduct of training and testing, supervised the overall conduct of the scenarios, and served as the Assistant Battle Master. The Event Coordinator, Battle Master, Floor Monitor, and others assisted the Exercise Director in ensuring proper execution of events. This permitted decentralized execution consistent with the research plan. The Event Coordinator worked out of the ECR to coordinate activities between the ECR, battalion TOC, and the vehicle simulators throughout the training and test scenarios.

Exercise control room staff. The Exercise Director, the Battle Master, two BLUFOR operators, two radio operators, an OPFOR operator, and a PVD monitor staffed the ECR. The Battle Master maintained primary responsibility for scenario execution. The Battle Master, assisted by the ECR staff, role-played the brigade commander and staff, adjacent and supporting unit personnel, and other tactical elements. He also presented the brigade OPORD (pre-mission briefing), and ensured that the ECR was set up prior to the start of each exercise. In addition, he supervised the ECR staff during execution to ensure strict adherence to the operating procedures and to the scenario events

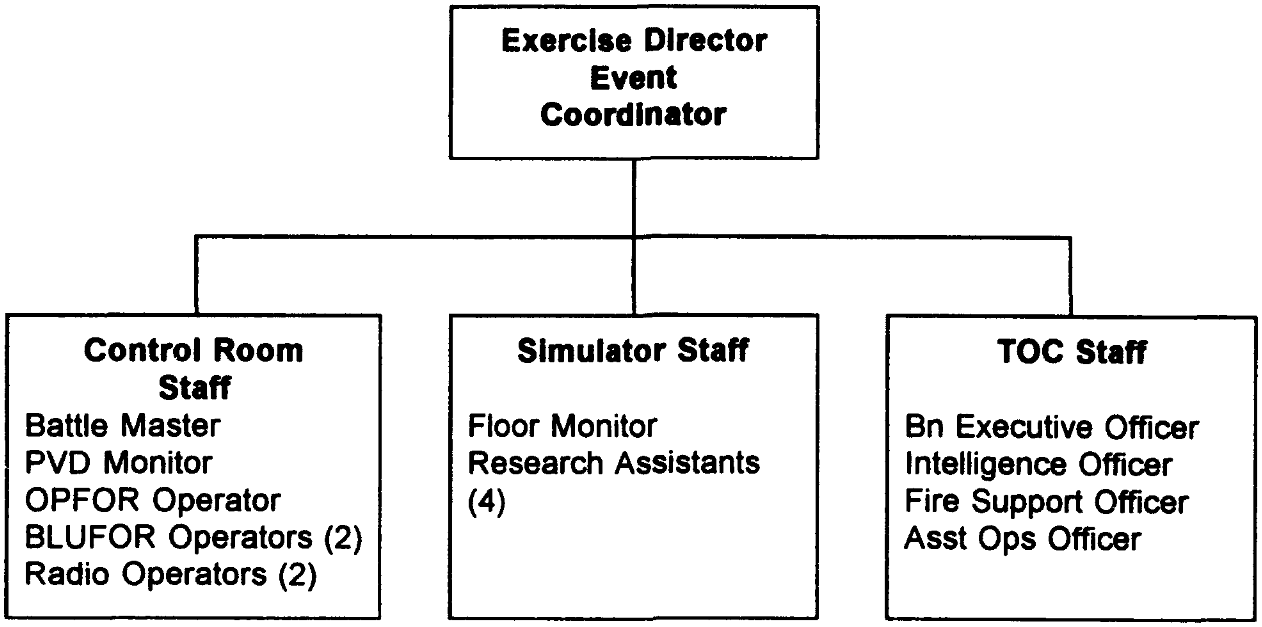

Figure 10. Exercise control staff organization during test scenario execution.

list. At the conclusion of each scenario, the Battle Master conducted the debriefing.

Simulator staff. Eight Research Assistants (RAs) served as vehicle trainers/monitors during individual and collective training. Their responsibilities included training participant crews on the operation of the simulators (Baseline and CVCC) and the CVCC equipment (CVCC only). During the test scenario, four vehicle monitors collected data on crew performance. The Floor Monitor supervised the trainers/monitors. The Floor Monitor also assisted the Event Coordinator by notifying site support staff of equipment malfunctions, and tracking repair progress.

TOC staff. Four research staff members manned the TOC, and assumed key roles in the battalion staff. TOC staff members were selected for their extensive military background: all were retired soldiers or members of the Army Reserve, with experience in TOC operations.

The senior TOC staff member assumed the role of battalion XO, and supervised staff operations. In addition, the XO conducted the battalion OPORD briefings and the stealth-based terrain reconnaissance for the test scenario. Other staff positions within the TOC were the Intelligence Officer (S2), Assistant Operations Officer (S3 Air), and FSO.

Limitations

There were several limitations to the simulation environment that must be considered in conjunction with this evaluation. Some of these are common to all simulations using the current SIMNET technology. Other limitations were unique to the CVCC simulation. This section summarizes the limitations, and their implications to the battalion evaluation.

SIMNET gunnery performance only approximates the system capabilities of an actual tank or the M1 COFT. The simulator's visual fidelity makes target identification difficult at ranges beyond 2000 meters, and the automatic lead does not accurately model the actual tank. As a result, crews often perceived that the simulators did not function properly in direct fire engagements. However, it is important to remember that both Baseline and CVCC crews used essentially the same simulator elements in direct fire engagements. There were no differences between conditions within the GPS/GPSE and gunner's controls. Furthermore, the emphasis on C^2 performance in the battalion evaluation minimized the impact of this limitation.

Another limitation of the basic simulator is that the system did not provide the same degree of visibility that is available in an actual tank, even when "buttoned up." This, along with other factors limited the crew's ability to navigate and to acquire targets through the vision blocks. The simulator contained navigational aids (i.e., the grid azimuth indicator and the hull-turret reference display) to help offset the navigation problem. Furthermore, Navigation training was an important part of the training program for Baseline units. Scenarios were designed to present targets within the tank's frontal arc in almost all circumstances, in order to offset the lack of 360° visibility. These factors should have reduced the potential impact of visibility on navigation in the Baseline condition, and target acquisition in general.

Within the CVCC condition, the digital network structure did not include an actual brigade network. Therefore, any relays from the battalion to the brigade echelon were notional. Also, there was no downward digital link from Company commanders to the SAFOR operators, and therefore no compelling reason for commanders or XOs to relay digital traffic to their subordinates. This latter limitation may have artificially reduced the number of digital reports relayed to the platoon echelon, and therefore resulted in the loss of data regarding information transfer between echelons. Separate research focusing on multi-echelon effects of digital communications was undertaken in conjunction with the battalion evaluation (see Lickteig, Williams, and Smart (1992).

Given that the RIU was not used for this evaluation, digital traffic did not compete with voice traffic on the FM radio network. Therefore, no valid conclusions can be made regarding

the unit's overall (i.e., voice plus digital) radio signature. Likewise, time-based comparisons between voice and digital message traffic were based on the simplifying assumption that digital transmissions would be nearly instantaneous, and are presented primarily for descriptive purposes.

Another limitation was that the network structure was not comparable between conditions. In the Baseline condition, the TOC, battalion commander, S3 and company commanders operated on the battalion command network. The TOC and company XOs operated on the battalion O&I network. Company commanders and XOs also operated on their internal company command networks. As a result, traffic passed on either battalion network had to be relayed at the company network if it was to be shared between the company commander and XO. In the CVCC condition, the same voice networks were in effect, but only one battalion level digital network existed, and all simulators had access to that digital network. Therefore, any digital reports that were transmitted at the battalion echelon were immediately available to both the company commander and the XO without having to be relayed.

All simulators operated with a feature known as "kill suppress." This feature effectively rendered the simulators invulnerable to enemy fires. Kill suppress was used to protect participant crews so that the data collection on their command and control performance would continue throughout the scenarios. During the officer's call on Wednesday afternoon of each test week, vehicle commanders were made aware of the kill suppress feature and its implications, and encouraged to play their assigned roles as if they were vulnerable. Nevertheless, crew performance was, on occassion, most likely affected by the use of kill suppress.

In both the Baseline and CVCC conditions, the short amount of training time available did not allow test groups to master all tasks. Since no test group came into the evaluation as an existing, combat unit, the lack of unit cohesion most likely limited their ability to operate as effectively as an existing organization. However, since all groups operated under these constraints regardless of condition, this limitation would not have had any implication on performance between groups. However, the short amount of training time also limited the opportunity for CVCC condition participants to experiment with the equipment, and therefore, limited their opportunity to discover or refine techniques and procedures appropriate to digital communications. This factor may have limited the performance of CVCC groups, and masked potential performance differences between conditions.

Finally, because the TOC was operated by contract personnel, TOC operations were standardized between iterations in order to control for possible contamination of the test data. The degree of standardization also inhibited experimentation that may have uncovered additional advantages of the CVCC system, or led to the development of additional C^2 techniques and procedures.

Results and Discussion

This section describes and discusses the results of the battalion evaluation, with emphasis on the tactically meaningful findings as well as the performance of unit commanders and company XOs. The presentation opens with a discussion of the comparability between test groups, and an overview of the results, followed by findings relevant to each of the four research issues, and implications that transcend two or more operating systems (i.e., battlefield integration). The section closes with a recap and summary of findings. The organization of data follows the evaluation's four operationally-based research issues: (a) command and control, (b) battlefield maneuver, including target engagement, (c) attack by indirect fire, and (d) collection of intelligence information.

Focusing on tactical performance and potential TTP applications, this report presents only part of the results from the battalion evaluation. Atwood et al. (in preparation) document the results pertaining to training and SMI issues, with a focus on questionnaire-based data and equipment usage measures. The data presented in this report are extracted primarily from Leibrecht et al. (in preparation) which presents operational effectiveness data using a more detailed, technically oriented analytical approach. The reader is encouraged to review all three reports for a complete account of the evaluation's findings and their implications.

The measures of performance supporting this evaluation have been summarized in the earlier Data Collection subsection of this report. O'Brien et al. (1992) defined the basic set of measures. However, several definitions have changed and a number of new measures have been developed since the battalion TOC evaluation. Leibrecht et al. (in preparation) present the updated definitions for the modified and new measures, along with selected measures chosen to provide an across-the-board sampling.

Circumstances in executing the evaluation occasionally led to missing data. Two Baseline battalions and one CVCC battalion completed only part of Stage 3 of the test scenario, making it unfeasible to compute some of the Stage 3 measures for those units. One CVCC battalion had no S3 or S3 crew. Therefore, that unit generated data for only seven of the eight planned crews. During one Baseline week, the S3 crew operated with no gunner. Target acquisition and engagement measures for that crew were excluded from the database. In addition, occasional equipment difficulties led to dropping impacted measures from the database.

The presentation of performance measures which follows is organized by the research issues outlined earlier in this report. The sequence within each issue's subsection follows the hypotheses supporting that research issue. Each subsection concludes with a summary of key findings distilling the noteworthy results. Data findings are clustered and shown

graphically to illustrate both demonstrated and potential benefits and shortcomings of the CVCC system.

The TTP implications presented in this section are a compilation of techniques observed during tests, suggested by participants after-the-fact in debriefings and questionnaires, and used by the TOC staff during the evaluation. TTP and operational effectiveness findings from previous efforts are also integrated where appropriate.

Comparability of Test Groups

The data regarding experience levels among the participants that were presented earlier in the Method section and Appendix B suggest that the Baseline groups were generally more experienced --both practically and academically--than CVCC groups. The differences in experience among officers are relatively minor, and the groups can be considered comparable across conditions. There are, however, significant differences between the Baseline and CVCC groups in the experience levels among NCOs and enlisted personnel.

Potential impact on data. The majority of performance data are concerned with the battalion's overall performance, as a result of C^2 processes, and are therefore influenced most directly by the performance of the officers. Since the officer population does not differ significantly, there should have been no impact on the data among C^2 measures. By contrast, direct fire engagement data among manned simulators could have been affected by the higher gunnery experience levels among Baseline NCOs and enlisted personnel. Since the primary focus of the battalion evaluation is on C^2 processes, the potential affect on direct fire performance was not a major concern.

Overview

Overall, C^2 processes were enhanced among CVCC units in several ways. Most notably, CVCC units used significantly fewer voice radio messages to accomplish all missions. At the same time, they enjoyed wider, more complete, and more consistent receipt and transmission of mission, enemy and own troop information. CVCC commanders operated with more accurate, up-to-date tactical information with regard to their own unit status and the enemy situation. However, these advantages did not yield measured differences between conditions in the units' ability to assess the tactical situation or to direct and lead subordinate forces.

CVCC units also maneuvered more effectively than did Baseline units. CVCC units maintained greater stand-off from the OPFOR, and achieved more advantageous loss-exchange ratios in two of the three stages, overall. In offensive missions, CVCC units met LD times more consistently, and reached their objectives earlier than Baseline units. CVCC units acquired OPFOR units

earlier and at greater distances in all stages. By contrast, CVCC units did not achieve any measurable advantage in their ability to control terrain within the evaluation.

The CVCC equipment enabled participants to send more accurate CFFs, CONTACT and SPOT reports, as compared to Baseline unit participants. These findings highlighted the advantage of the CVCC system with respect to fire support target processing and intelligence collection.

The reduced acquisition time, improved tactical reporting, and enhanced agility attributed to the CVCC system have important implications for the employment of advanced C^2 systems. These capabilities would enable the commander to reposition his force with greater agility to gain and maintain positions of advantage over the enemy, and to assume or retain the initiative in tactical operations. Most important, CVCC would allow the commander to be more proactive as he attempts to influence the battle and operate within the enemy's decision cycle.

Command and Control

Issue: Does the CVCC system enhance the Command and Control BOS?

The CVCC system enhanced the unit's ability to command and control their activities. The real-time tactical displays in the TOC and command vehicles provided the commander an accurate, up-to-the-minute picture of his own unit situation. Digital message capabilities enabled the entire unit to receive and relay FRAGOs almost instantly. Graphic displays enhanced inter-unit coordination, and voice radio nets were far more accessible to commanders and staff, to further facilitate coordination and information sharing. This subsection presents C^2 techniques and procedures used during the evaluation, followed by the presentation of performance data, and culminating in a summary of Command and Control BOS findings. The performance-based results within the Command and Control BOS are organized according to the six C^2 functions: Receive and transmit mission, receive and transmit enemy information, receive and transmit friendly troop information, manage means of communication, assess situation, and direct and lead subordinate forces.

Command and Control Techniques and Procedures

The automated position reporting features of the CVCC system provided a significant advantage throughout the unit, with respect to maneuver coordination and position monitoring. Commanders and staff at every level could observe the performance of subordinates and adjacent elements on the CCD and TOC workstation map displays. When necessary, verbal communication (e.g., directions or suggestions to adjust march speeds or positions) enhanced that coordination.

In order to maintain an accurate unit status, operators in the automated TOC posted the battalion operational effectiveness summary charts in a conspicuous location on their workstations. Also, a corner of the large screen SitDisplay was dedicated to the operational effectiveness summary chart. As such, when unit status changed, the TOC could quickly recognize that development. Given that vehicle commanders could not permanently post the logistics module, the TOC was able to verbally alert the battalion commander to changes in the unit status almost as soon as they happened. In several cases, the TOC recognized the change in a company's equipment status even before the company commander was able to calculate his losses.

During the preparation period, the TOC staff used a concept of operations overlay to demonstrate the anticipated scheme of maneuver during the delay. This type of overlay would also be an effective planning tool, in that it enables the staff to visualize a course of action from one phase of the operation to the next. As configured for the battalion evaluation, the concept of operation overlay could only model the BLUFOR's proposed course of action. OPFOR reactions and counteractions could not be portrayed in the same, time-sequenced fashion. This constituted a minor shortcoming, but the effectiveness of the concept of operation overlay could be enhanced by expanding the multi-phase capability to the intelligence estimate.

Throughout the operation, the S2 maintained a working estimate of the enemy situation in overlay form. The S2 integrated data from subordinate and adjacent sources, and higher headquarters. The overlay could be provided to the command net on demand to provide a synthesized, "big picture" update of the enemy situation.

The CVCC system proved particularly helpful in planning the FRAGOs during the operation. In Stages 1 and 2, brigade FRAGOs were received at points of the battle when it was either not feasible or inadvisable for the commander or S3 to return to the TOC. However, they were able to receive and post the digital FRAGO overlay and text on their CCDs, and therefore participate substantially in the planning process. As the commander developed a concept for the FRAGO mission, he communicated that in brief terms to the XO and S3 Air. The S3 Air drafted a battalion operations overlay to support the commander's concept, and then transmitted the overlay on the battalion net for approval or refinement, all within a very short period of time. Given the commander's approval, the S3 Air could then develop the FREE TEXT message to accompany the overlay. This message would contain critical mission information such as the mission statement, critical subordinate unit tasks, and coordinating information that could not be shown graphically (see the digital texts to FRAGOs 1-200 and 2-200 in Appendix C). Subordinate commanders, if not engrossed in the current battle, could eavesdrop on the entire process, and would therefore have significantly more information than would otherwise be available

to them regarding the subsequent operation. Assuming digital links with brigade and adjacent units, the final FRAGO plan could also be transmitted for coordination, greatly improving the liaison process.

When company commanders received the FRAGO, they could relay the entire battalion FRAGO exactly as they received it to their subordinates. The CCD had no drawing program that allowed commanders to integrate sub-unit graphics (e.g., platoon BPs). However, many commanders generated routes using the navigation function, and transmitted them to their subordinates in order to specify either directions of attack in the offense, or critical points such as objectives or BPs. These digital tools, along with brief voice transmissions enabled CVCC units to tailor the FRAGO effectively at company level.

Throughout CVCC operations, participants used verbal transmissions to enhance digital communications and to alert each other to critical events. In many cases, verbal information was redundant, but it did help call participants' attention to important tactical developments such as initial contact and status changes.

Receive and Transmit Mission

Hypothesis: The CVCC units' ability to receive and transmit information on the battlefield was expected to be significantly better than the Baseline units'.

The performance measures that supported this hypothesis captured the duration of FRAGO transmissions, the number and duration of related, clarifying transmissions, and the consistency of FRAGOs received on the company command nets. CVCC units could transmit the complete FRAGO virtually instantaneously. Baseline units took much longer to relay FRAGOs to all subordinates, and the orders that were relayed excluded much of the pertinent information in the original FRAGO. Furthermore, Baseline units consistently required a series of voice radio transmissions to clarify the FRAGOs, whereas CVCC units rarely needed to discuss the digital FRAGO. In effect, both the rapid burst transmission of digital FRAGOs and the clarity of information communicated therein contributed to speed FRAGO dissemination.

Elapsed time from battalion transmission of FRAGO to receipt by company commander/XO. This measure was defined as the total elapsed time between the time the battalion TOC initiated transmission of a FRAGO to the time the last company commander finished transmitting the FRAGO, to include any transmissions clarifying the order. The data are illustrated in Figure 11. In CVCC battalions, the FRAGOs were received almost instantaneously by all unit commanders and their XOs via digital burst transmission. Two CVCC commanders requested clarification of the FRAGO to resume the delay following the counterattack, resulting

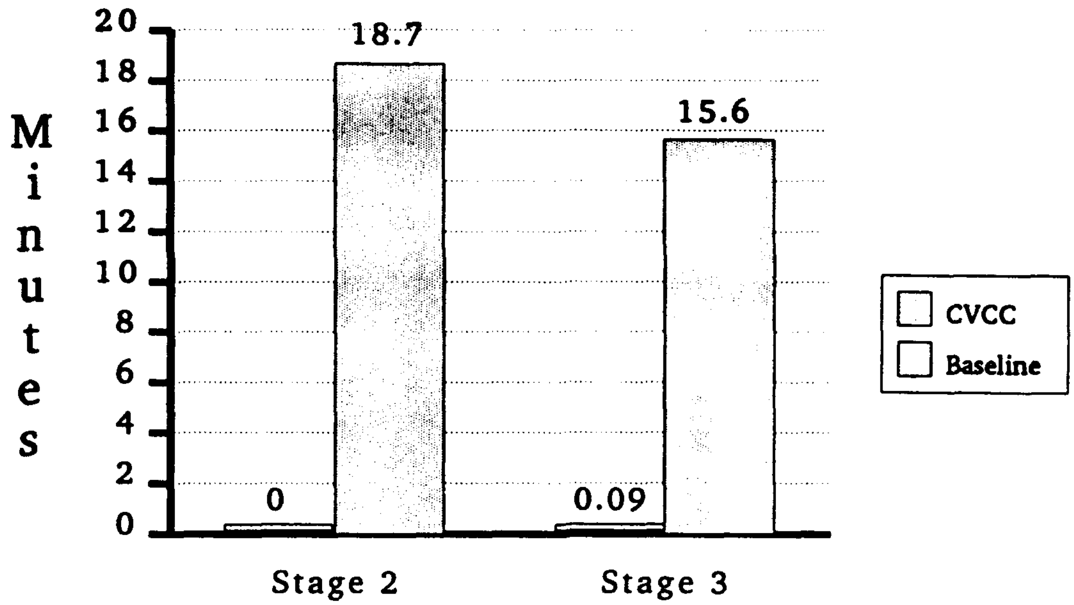

Figure 11. Mean elapsed time to transmit FRAGO.

in an average of 0.09 minutes elapsed time for CVCC units in Stage 3. In the Baseline condition, average times ranged from 9.5 to 27.22 minutes (average 18.65 minutes) in Stage 2 of the exercise and 6.18 to 26.05 minutes (average 15.65 minutes) in Stage 3.

Number of requests by company commander/XO to clarify FRAGO/overlay. This measure reported the average number of company commander's and XO's unique requests for clarification of a FRAGO and/or the accompanying overlay. A unique request was defined as a single question, raised by a given participant, in a single transmission. For example, if a company commander asked, "Where is BP 45," received an answer, then asked, "Where is BP 35," that constituted two unique requests. By contrast, if he had asked, "Say again location of BPs 35 and 45" in the original transmission, that was interpreted as a single, unique request. Data for this measure were only collected for Stages 2 and 3.

In both stages, there was a notably higher number of requests for clarification among Baseline units. In Stage 2, there were no requests among CVCC units, as opposed to .33 requests per vehicle among Baseline units. In Stage 3, there were .08 requests per vehicle among CVCC units, and .53 requests per vehicle among Baseline units. These data are graphically illustrated in Figure 12. The lower number of requests for clarification in CVCC may be attributed to the clarity of the digital FRAGO, as demonstrated by the consistency of received FRAGOs discussed later in this subsection.

Duration of requests by company commander/XO to clarify FRAGO/overlay. This measure reported the average length of transmissions required to clarify the FRAGOs (Stages 2 and 3

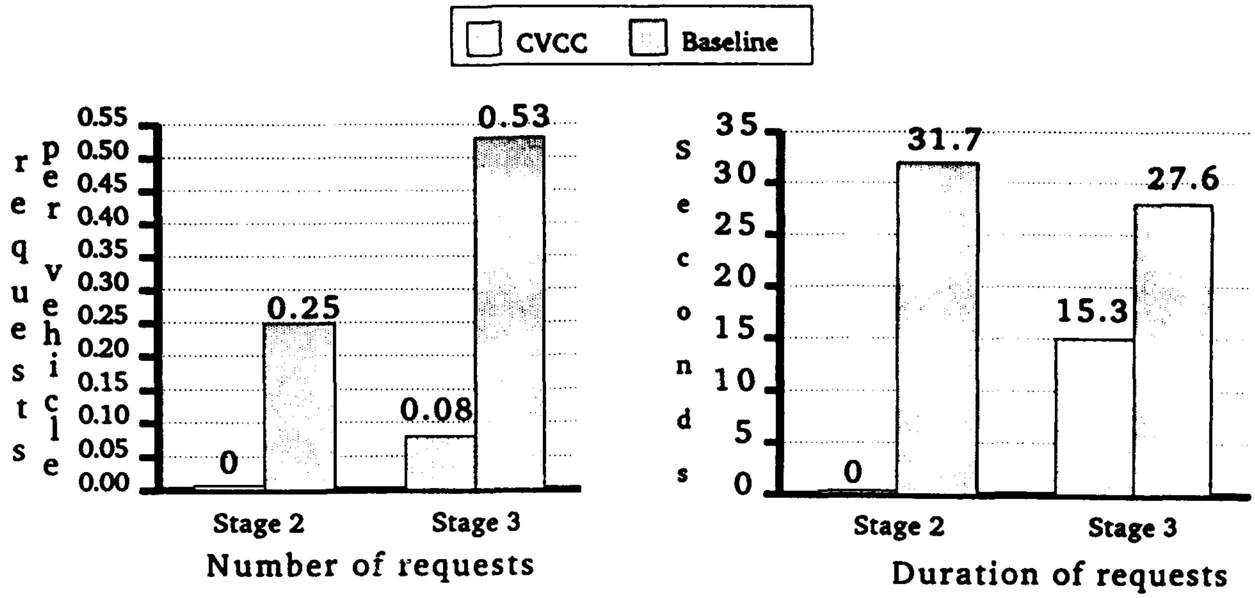

Figure 12. Mean number and duration of requests to clarify FRAGOs.

only). Figure 12 illustrates the data for this measure. As shown, requests for clarification took significantly longer, on average, in Baseline units, on a per-request basis. Taken in conjunction with the preceding measure, two important factors emerge: (a) The digital FRAGOs were better understood, as evidenced by both fewer requests for clarification and shorter requests when clarification of the digital FRAGO was required; and (b) requests for clarification in Baseline units required a relatively large amount of radio air time, as suggested by both the number and duration of requests.

Consistency of FRAGO received. FRAGO consistency among Baseline units was measured by comparing the information transmitted on the company command network to a scoring template (see O'Brien et al., 1992) that contained key information from the scripted FRAGO. The results are presented in Figure 13. In the CVCC condition, all manned simulators received the FRAGO/overlay simultaneously. As such, error-free content was assumed for digital orders. For the Baseline condition, the average percentage of information relayed correctly was 19% in Stage 2 and 35% in Stage 3. In practical terms, Baseline units sacrificed from 65 to 81% of the FRAGO content due to either transcription error or lack of time.

Summary. These data demonstrate a substantial advantage of the CVCC system over the Baseline: Baseline units used, on average, 34 minutes of radio air time per scenario relaying and clarifying mission information, and only correctly relayed an average of 27% of the FRAGO information to their subordinates. Digital communications sped FRAGO dissemination, and digital FRAGOs were more easily interpreted and implemented. Digital

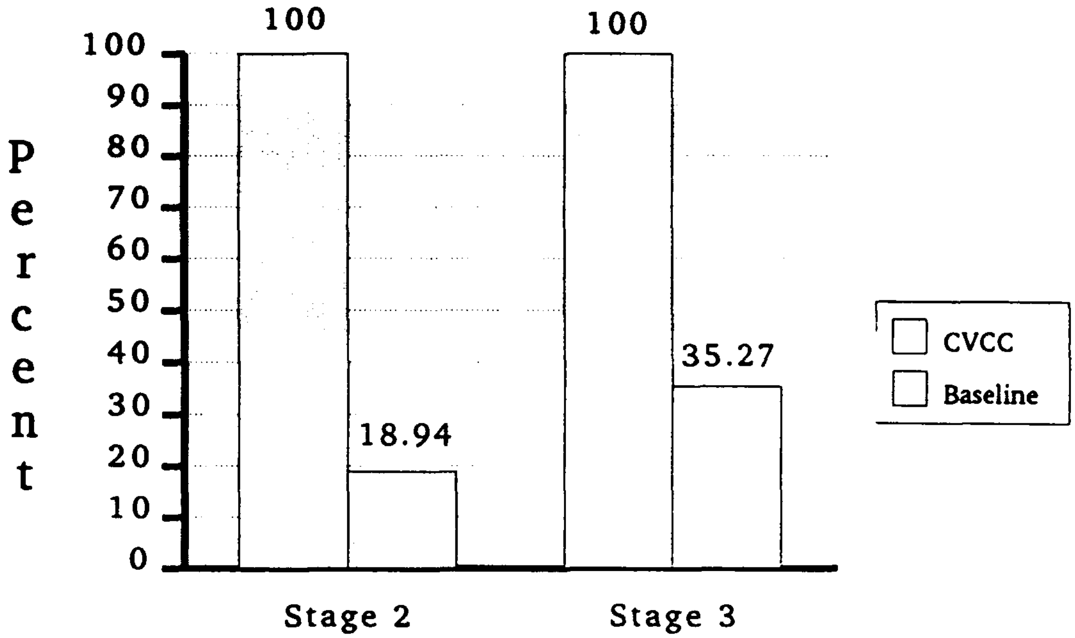

Figure 13. Mean consistency of information content in FRAGOs received on the company command network.

communications substantially reduced the time necessary to transmit mission information, and enhanced both the quantity and quality of information that was conveyed.

Receive and Transmit Enemy Information

Hypothesis: The CVCC units' ability to receive and transmit enemy information on the battlefield was expected to be significantly better than the Baseline units'.

The data used to evaluate this hypothesis quantified the duration of INTEL report transmissions, the consistency of information received on the company command network, and the number of requests to clarify intelligence data. Also, the number of INTEL reports transmitted on company command networks was tallied as a part of the data processing routine. Throughout the battalion evaluation, CVCC units were able to distribute significantly more tactical intelligence than Baseline units, both in terms of quality (consistency with the original report) and quantity.

Consistency of INTEL received. INTEL report consistency was defined as the percentage of scripted INTEL elements (i.e., size, type, number and location of units) transmitted on the company command network. The scoring was accomplished using a scoring template similar to that used for FRAGOs (see O'Brien et al., 1992). As with FRAGOs, the consistency of information received was assumed to be error-free in the CVCC condition. Figure 14 portrays the results from this measure.

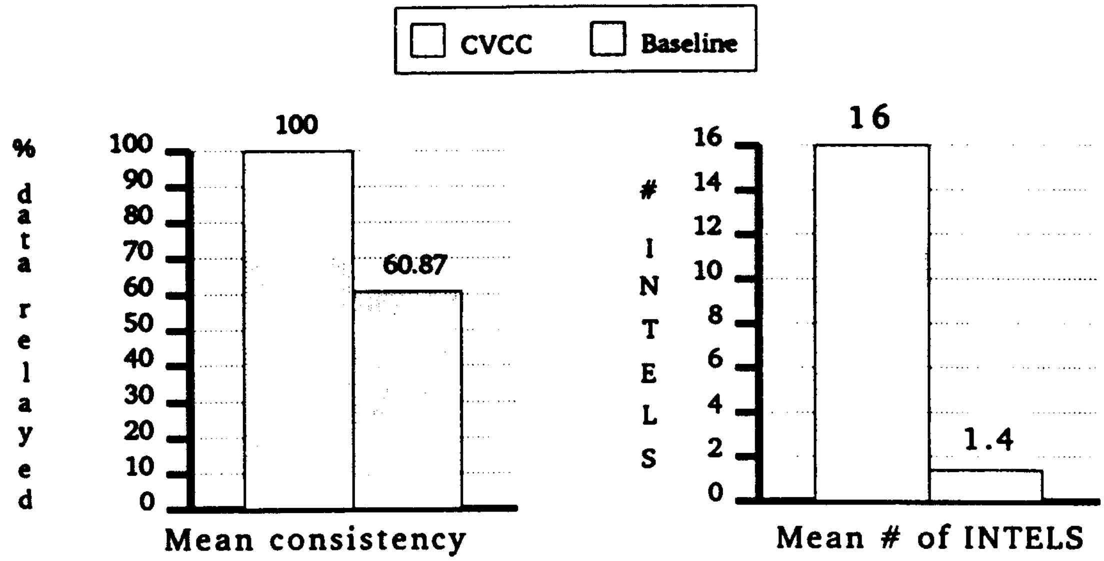

Figure 14. Mean consistency of information in INTEL reports, and mean number of INTELs received at the company echelon per scenario.

In Baseline, only a small number of INTEL reports (8) could be scored. As shown in Figure 14, this correlates to only 1.4 INTELS per scenario, as compared to sixteen scripted messages. Across all Baseline groups, only six INTEL reports were relayed in Stage 1. The consistency score for those reports averaged 60%, and ranged from 0% to 100% consistent. Only one report each was scorable in Stages 2 and 3. Consistency scores for those reports were 100% and 25%, respectively. Overall, less than 10% of the scripted INTEL reports were relayed on the company network among Baseline units, and only 61% of the scripted information was relayed in those cases. By comparison, all CVCC participants received each INTEL, in its entirety.

There are two possible explanations for the low number of reports received in the Baseline condition. The first is a matter of relevancy. Company commanders may not have relayed INTEL reports that they did not consider relevant to their subordinates. The second is a matter of priority. When the company was in contact, INTELs that did not bear on the immediate situation would not have been copied (let alone relayed), in favor of more critical tactical information. Furthermore, if the commander inadvertently "tuned out" some critical information, there was only a slight chance of that information being recovered at a later point, when it may have been more convenient.

In CVCC, the commander or XO could ignore a received report if current contact so dictated, and then retrieve it later. Once the INTEL was opened, it was as easily relayed as not, and subordinates could likewise view the report immediately or let it "time out" of the receive queue and retrieve it later. Also,

voice transmissions were often used to highlight or summarize critical INTELs. Since the voice net was more accessible (see "Manage means of communication," later in this subsection), it was easier to pass information verbally, or to call attention to digital reports in CVCC units.

<u>Time to transmit INTEL reports full net: Battalion TOC to lowest manned net</u>. This measure is defined as the elapsed time between the initiation of an INTEL transmission from the TOC until the message was relayed to the last manned vehicle. Only INTELs ultimately relayed at the company level were included in the data. In Baseline condition, relay times averaged 1.58 minutes overall, and ranged from 0.57 to 3.63 minutes. In the CVCC condition, all INTEL reports were received simultaneously on the battalion's digital net.

<u>Number of requests to clarify INTEL reports</u>. This measure reports the average number of vehicle commander's unique requests to clarify INTEL messages. A unique request was defined in the same manner as a unique request for FRAGO clarification. The data for this measure show an average of .02 requests per scenario per vehicle among CVCC units, as opposed to .15 requests per scenario per vehicle among Baseline units. Figure 15 illustrates the average number of requests per vehicle per stage. The difference between conditions is too small to characterize as any more than a trend, but is nevertheless descriptive of the same kind of trend demonstrated previously in the FRAGO clarification measure.

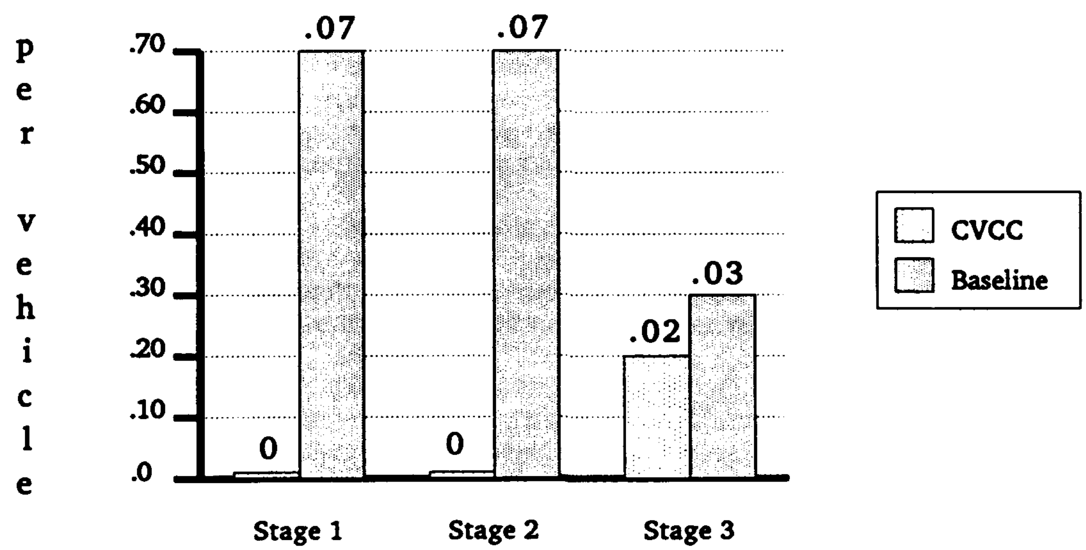

Figure 15. Mean number of requests to clarify INTEL reports, per vehicle.

<u>Summary</u>. CVCC units were able to disseminate INTEL reports more widely, rapidly, and with greater consistency than Baseline units. Furthermore, the CCD allowed the vehicle commander to

easily recall or review information that he may have chosen to ignore when his unit was engaged in close combat. These findings indicate that the CVCC system improves the unit's ability to communicate enemy information. The ease with which enemy information was disseminated in CVCC has important implications for improved situational awareness. To the extent that graphic displays enabled the unit to literally "paint" the enemy situation, commanders were better informed.

Receive and Transmit Friendly Troop Information

Hypothesis: The CVCC units' ability to receive and transmit friendly troop information on the battlefield was expected to be significantly better than the Baseline units'.

The data for this function measured the average times to transmit SITREPs, the average number and duration of voice transmissions between the TOC and the battalion commander and S3, and the timeliness of position reporting. Due to a low number of observations during Stage 3, only Stages 1 and 2 were analyzed for the measures, "average duration of voice transmissions between the TOC, battalion commander, and S3," and "number of transmissions from the commander or S3 to the TOC." This was primarily attributed to the absence of a Brigade-level FRAGO in the last stage of the scenario. Most of the coordination between the battalion commander, S3 and the TOC in Stages 1 and 2 dealt with processing the Brigade FRAGO.

Baseline battalion command groups spent significantly more time on the radio coordinating and directing subordinate units than CVCC command groups. The real-time tactical displays available in both the CVCC TOC and vehicle simulators provided CVCC units a more accurate picture of their own unit status, as compared to Baseline units. Table 16 provides summary data from the measures supporting this hypothesis.

Mean time to transmit SITREP full net: lowest net to battalion TOC. This measure was defined as the elapsed time from the transmission of a SITREP on a company net until the company SITREP was received by the battalion TOC.

In the Baseline condition, average times were 3.05 minutes in Stage 1, 2.61 minutes in Stage 2, and 2.75 minutes in Stage 3. By contrast, the CVCC equipment allowed unit leaders to compile SITREPs in a significantly different manner than in Baseline units, such that no relay was necessary. In most cases, CVCC company XOs did not have to consult subordinate platoon leaders for SITREP data, because they could rely on CCD displays to gather most of the pertinent information. Furthermore, given automated position and unit status reporting at all levels, almost all of the SITREP data were redundant in CVCC units.

Three pieces of tactical information in the SITREP format were not constantly displayed via the position and status

Table 16

Performance Data for Receive and Transmit Friendly Information Hypothesis

Measures	Stage 1 CVCC	Stage 1 Baseline	Stage 2 CVCC	Stage 2 Baseline	Stage 3 CVCC	Stage 3 Baseline
Mean time to transmit SITREP full net (minutes).	NA	3.05 (2.84) n=52	NA	2.61 (2.16) n=32	NA	2.24 (1.72) n=25
Mean duration of communications between TOC, Bn commander and S3 (minutes).	0.56 (0.58) n=42	0.51 (0.57) n=142	0.52 (0.47) n=20	0.45 (0.37) n=88	NA	NA
Number of voice transmissions from the Bn commander and S3 to the TOC	5.17 (5.56) n=6	13.5 (10.67) n=6	1.83 (1.83) n=6	9.50 (7.89) n=6	NA	NA
Delay between observed event and report to TOC (minutes).						
PL/LD crossing.	0.91 (1.59) n=10	1.13 (1.45) n=12	1.28 (1.04) n=12	0.73 (0.72) n=6	0.43 (0.30) n=4	-.- n=0
BP arrival.	1.36 (1.58) n=11	3.29 (3.83) n=12	1.79 (0.15) n=3	2.26 (3.93) n=5	5.43 (3.90) n=4	2.57 (3.53) n=3

Note. Standard deviations appear in parentheses below the means. NA = not applicable.

reporting system: The enemy's action (type and level) and the reporting commander's intent. Digital reports and voice messages would easily fill in that information to allow a superior commander in a combat vehicle, or staff member in the TOC to ascertain the subordinate unit's situation. For example, the most recent CONTACT, SPOT, and CFFs from a company would indicate the enemy's current activity, while coordinating transmissions or verbal updates from the friendly company commander would indicate the friendly company commander's current intent. As a result, unit-generated SITREPs could be dropped from routine reporting requirements when using CVCC equipment.

Mean duration of voice radio transmissions between the battalion TOC and the battalion commander or S3. This item was designed to capture the average length of voice transmissions of other than named reports (e.g., named reports include SPOT, SITREP, INTEL). These transmissions primarily included coordination, analysis, and other general information-sharing activities between the commander, S3, and TOC. The average durations (see Table 16) do not yield any difference between

conditions; however, when considered in conjunction with the number of transmissions (following), the difference is notable.

<u>Number of voice transmissions from the battalion commander and S3 to the TOC, excluding named reports</u> (Stages 1 and 2 only). This measure quantified the total number of voice radio transmissions from the battalion commander or S3 to the battalion TOC. Besides those transmissions originated by the participants, this measure also included requests for guidance, unscripted traffic and questions from the TOC that required command decisions. The measure excluded named reports and verification that FRAGOs or named reports have been received. For example, coordination between the Battalion Commander and XO regarding a Brigade FRAGO or the emplacement of an artillery-delivered scatterable minefield would be included whether initiated by the TOC or the commander. Likewise, a recommendation from the TOC that a unit begins movement to meet an LD time would be included. By contrast, TOC-initiated updates on either the friendly or the enemy situation would not be included, unless requested by the commander of S3.

CVCC units sent substantially fewer voice radio messages than Baseline units, as shown in Table 16 and as illustrated in Figure 16. When the data from this and the preceding measure are combined, the difference between conditions becomes even more apparent. The more frequent occurrence of transmissions among Baseline units led to notably more radio air time spent coordinating tactical details in the Baseline condition.

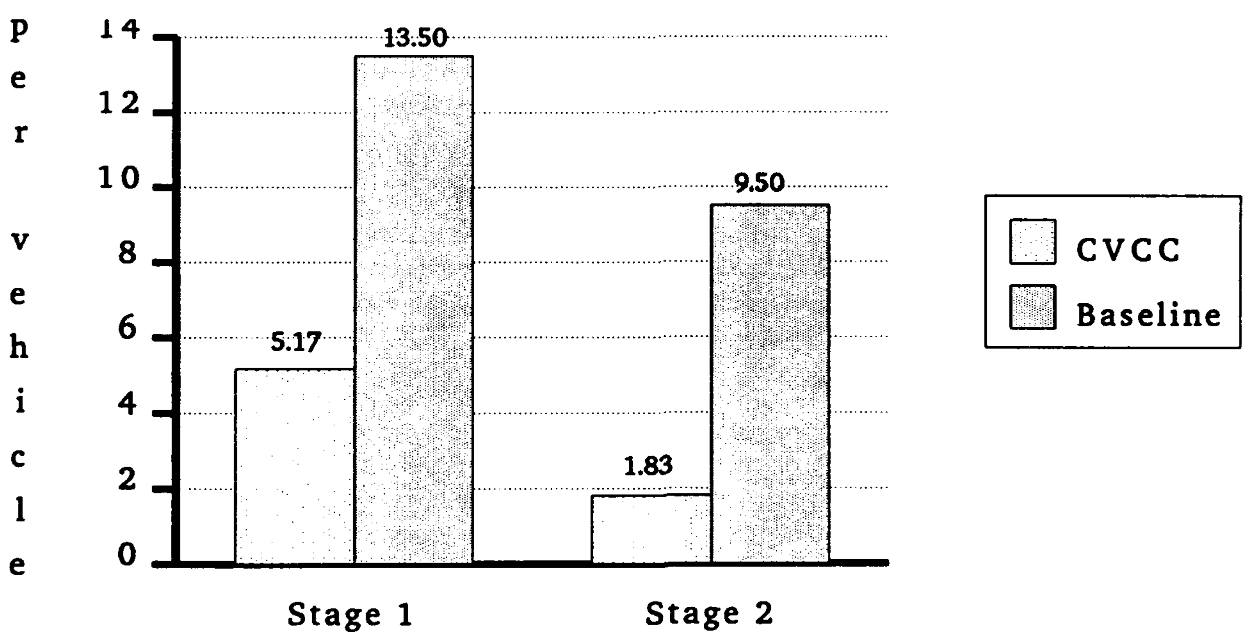

Figure 16. Average number of voice transmissions from the battalion commander and S3 to the TOC, excluding named reports.

Delay between observed PL/LD crossing and reported crossing. This measure gauged the amount of time, in minutes, between the observed crossing of a linear control measure and the company's corresponding report to the TOC. As seen in Table 16, the data for this measure do not yield any significant differences.

Delay between observed arrival and reporting set at BP. This item assessed the elapsed time from a unit's observed arrival in a battle position, and when that company reported "set" in the BP on the battalion command net. In the counterattack stage, the objectives were treated as BPs. No meaningful trends emerged among these data (see Table 16).

When the CVCC system's capabilities are compared to the data for both linear and area control measures, an important advantage of the CVCC system becomes apparent. In the Baseline condition, the battalion commander relied heavily on voice radio traffic to monitor the flow of the battle. Overall, Baseline commanders received periodic information that averaged over 2 minutes old, and was up to nearly 13 minutes old on occasion. In CVCC, the CCD provided the commander with constant, up-to-the-minute position information on all his forces. Therefore, voice reports were redundant.

It should be noted that voice transmissions in the CVCC condition were still important. In the case of positioning, a verbal report often served a valuable coordinating function, particularly if other actions (e.g., lifting or shifting fires) were tied to a unit crossing a phase line or arriving in a position. Furthermore, arriving at a BP or objective is not the same as being established in that position. In those cases, a verbal progress report (e.g., "Seizing RAIN now, SET in five") would provide important additional information. Therefore, although they may have been redundant, verbal position reports need not be eliminated.

Summary. The CVCC system enhances the communication of friendly troop data. A common participants' comment during CVCC debriefings was the observation that unit commanders had an excellent picture of the unit's situation throughout the battle. By contrast, Baseline commanders often reflected that they had difficulty keeping track of the friendly unit situation (Meade, Fergus, Pollock, Cash, and Lozicki, in preparation). Given the automated position and operational effectiveness data available through the CCD, and the reduction of voice radio traffic between conditions, the CVCC system clearly enhances the ability to access and interpret friendly unit information. As with enemy information, these capabilities have significant implications for improved situational awareness in CVCC units.

Manage Means of Communicating Information

Hypothesis: The CVCC units' ability to manage means of communicating information on the battlefield was expected to be significantly better than the Baseline units'.

Data for this function were taken from four measures: the average number of voice transmissions, the average length of voice transmissions, the total time on radio nets, and the average number of named voice reports. Overall, the duration of individual transmissions were comparable across conditions, but CVCC units sent significantly fewer voice transmissions than Baseline units, and therefore significantly reduced the units' voice radio signature.

Average number of transmissions. This measure tallied the number of transmissions from simulators only, during each stage. In other words, transmissions from the TOC, ECR, and SAFOR operators (i.e., support staff) were excluded. A transmission was defined as the keying of a microphone on a radio network. Transmissions of less than one second and greater than 30 seconds were excluded, to eliminate both "hot mike" events and "clicking" events. Stage 3 data are excluded from this measure, due to the differences between it and the preceding stages (e.g.: the lack of a Brigade FRAGO).

Significant differences occurred between conditions on every network when average number of transmissions were considered. There were far fewer voice transmissions made in CVCC than in the baseline condition. Figures 17 and 18 clearly show the extent to which digital communications reduced voice radio traffic. Differences were also found between scenario stages.

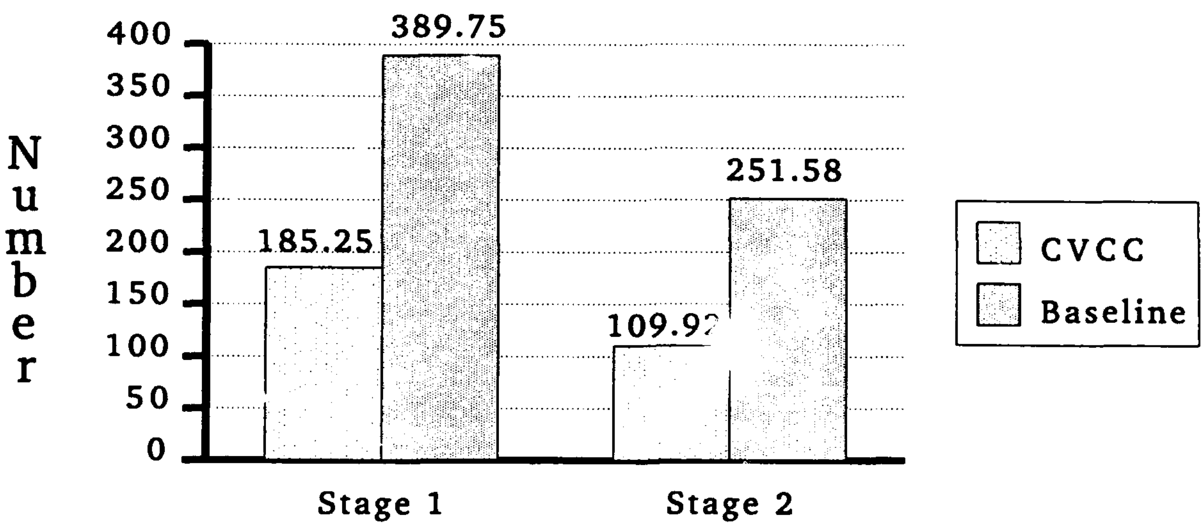

Figure 17. Average volume of voice radio transmissions on battalion nets.

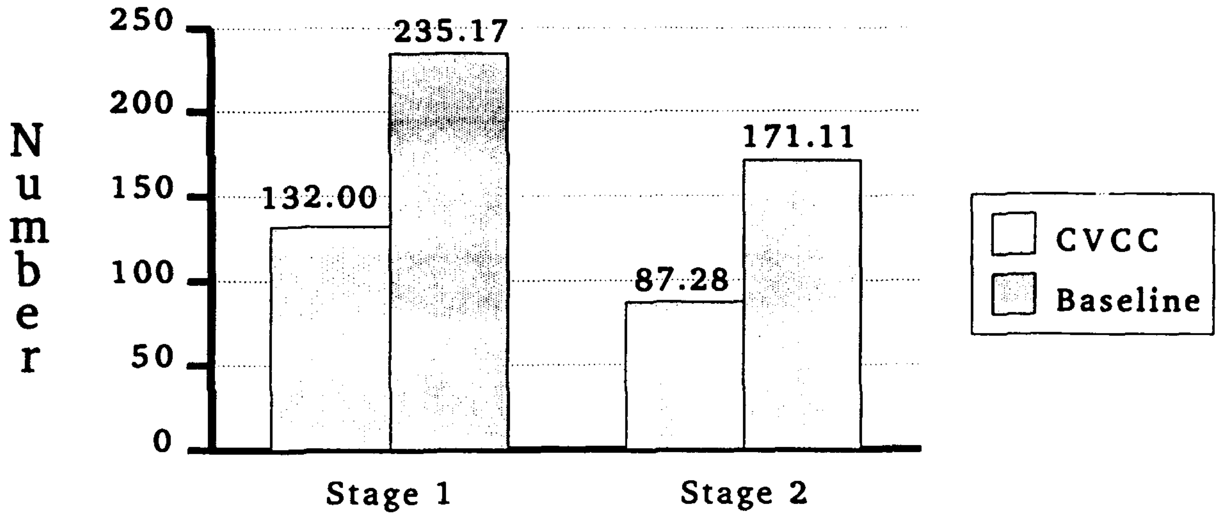

Figure 18. Average volume of voice radio transmissions on company nets.

The differences between stages are explained by a variety of factors, including varied stage lengths and the nature of the missions (explained previously). Actual run times varied between iterations (see Time to complete stage under the Maneuver BOS).

On the battalion command network, the number of transmissions across Stages 1 and 2 was 1.9 times greater in Baseline than in CVCC. On the O&I net, the differences were even greater, with Baseline units transmitting 3.2 times as often across both Stages. On company networks, CVCC units averaged 109.6 transmissions per stage, as compared to 202.6 transmissions per stage in Baseline.

Average length of voice radio transmissions. This measure captured the average duration of voice radio transmissions, in seconds, from simulators only. The same criteria applied to the previous measure was used for this measure.

The lengths of voice transmissions did not differ significantly between conditions or stages. Overall, voice transmissions averaged between 3 to 4.5 seconds. This finding suggests that the availability of digital communications does not directly influence soldiers' behavior when communicating by voice.

Total time on voice radio network. This measure represents the cumulative time on the network for all simulators. The data (see Table 17) were only computed for Stages 1 and 2, and are segregated by tactical radio network. No data appear for the Brigade O&I network because only the TOC and ECR operated on that frequency. As expected, given the number of transmissions reported earlier, Baseline units spent consistently more time on the voice radio net than CVCC units.

Table 17

Average Time on Net, in minutes

Radio network	Stage 1 CVCC	Stage 1 Baseline	Stage 2 CVCC	Stage 2 Baseline
Brigade Command	4.67 (1.60)	9.55 (5.60)	1.90 (0.48)	2.93 (2.39)
Battalion Command	20.34 (5.55)	35.98 (6.11)	12.08 (4.62)	25.56 (7.26)
Battalion O&I	5.25 (1.95)	17.52 (4.18)	2.86 (2.30)	10.12 (3.38)
A Company Command	9.86 (4.30)	16.04 (5.32)	5.82 (3.57)	10.68 (2.30)
B Company Command	9.10 (0.86)	14.51 (1.31)	5.81 (1.36)	11.01 (1.69)
C Company Command	4.72 (1.15)	15.51 (2.61)	4.75 (0.91)	12.29 (3.81)

Note. *n* = 6 for all cells.
Standard deviations appear in parentheses below the means.

Number of named voice reports. This measure reported the number of named voice reports sent in each condition.[13] In Baseline condition, this measure indicated the average number of named reports communicated per vehicle, per stage. In CVCC condition, it portrays the average number of named reports sent by voice per vehicle, per stage. This measure excludes reports generated by subordinate SAFOR and merely relayed by participants. The data presented here represent Stages 1 and 2 only, in order to maintain consistency with other measures supporting the manage means of communication function. For the sake of brevity, only composite data are presented in this report. For greater detail, see Leibrecht et al. (in preparation).

Overall, Baseline unit and vehicle commanders sent an average of 9.67 named reports per vehicle per stage, as compared

[13]Named voice reports were those corresponding to digital report formats: CONTACT, SPOT, SHELL, INTEL, SITREP, CFF, ADJUST fire, NBC, FUEL status, and AMMO status.

to 2.09 named voice reports per manned CVCC vehicle per stage. Company commanders and XOs sent most of the named reports in both cases, with Baseline company commanders and XOs contributing an average of 12.29 named reports each, per stage, and CVCC company commanders and XOs submitting an average of 2.40 named voice reports each, per stage. These data are illustrated in Figure 19.

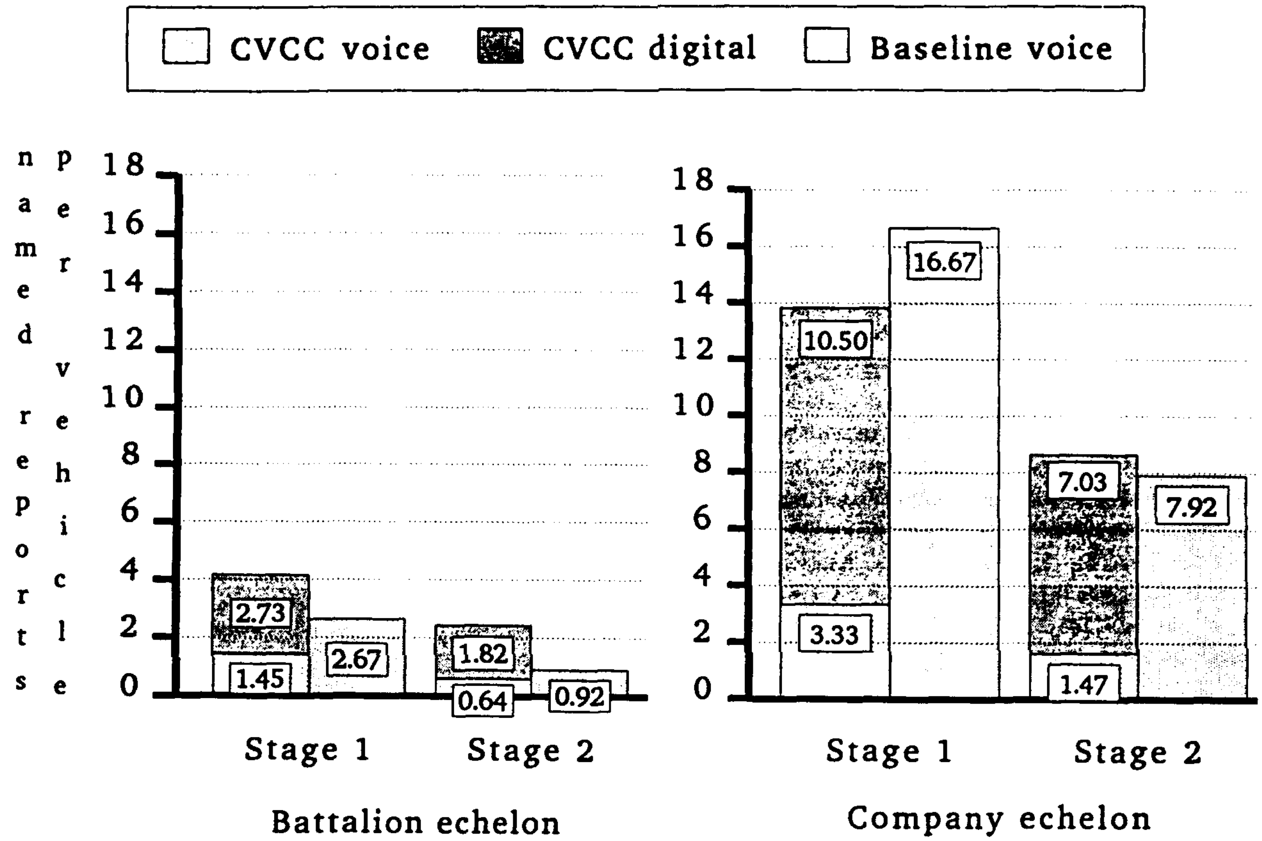

Figure 19. Average number of named reports (all types) sent per vehicle per stage.

For CVCC units only, Figure 19 illustrates the average number of both voice and digital reports sent per vehicle in a stacked bar format. Overall, CVCC units generated approximately the same amount of information as Baseline units, but at a significant reduction in voice traffic.

<u>Summary</u>. The number of transmissions and time on voice net data demonstrate an important operational benefit of digital communications technology: the profound reduction in voice traffic. The enhanced accessibility of command networks was remarkable. Participants' debriefing comments help illuminate the difference: Baseline participants often expressed frustration at being unable to enter the battalion command network to report critical events. By contrast, CVCC unit commanders often expressed wonder that the command net seemed so quiet (Meade et al., in preparation).

The reader is reminded that the radio interface unit (RIU) was not in operation for this evaluation. Therefore, voice and digital transmissions did not compete for radio air time. It is not appropriate to draw any conclusions regarding the unit's overall radio signature from the data presented here. It would be reasonable to assume that digital burst transmissions would increase the amount of time that radio nets were active in the CVCC condition, but the practical affect will have to be determined through additional research.

<u>Assess Situation</u>

Hypothesis: The CVCC unit leaders' assessment of battlefield events was expected to be significantly better than the Baseline units'.

Situational assessment was measured using a questionnaire that was administered to all vehicle commanders at the conclusion of the final test stage. The questionnaire consisted of five items relating to the friendly and enemy situation during the final stage. Besides reporting factual data, the participants were also asked to register the degree of confidence they had in their response to each item. Each item therefore yielded two measures. The factual responses were scored against automated data, and in addition to being reported individually, were also compiled into a composite situational assessment index. The data reported for individual items did not reveal any substantial differences between conditions. Those data are presented by Leibrecht et al. (in preparation), and are excluded from this report for the sake of brevity. The results of the composite index are presented in Figure 20.

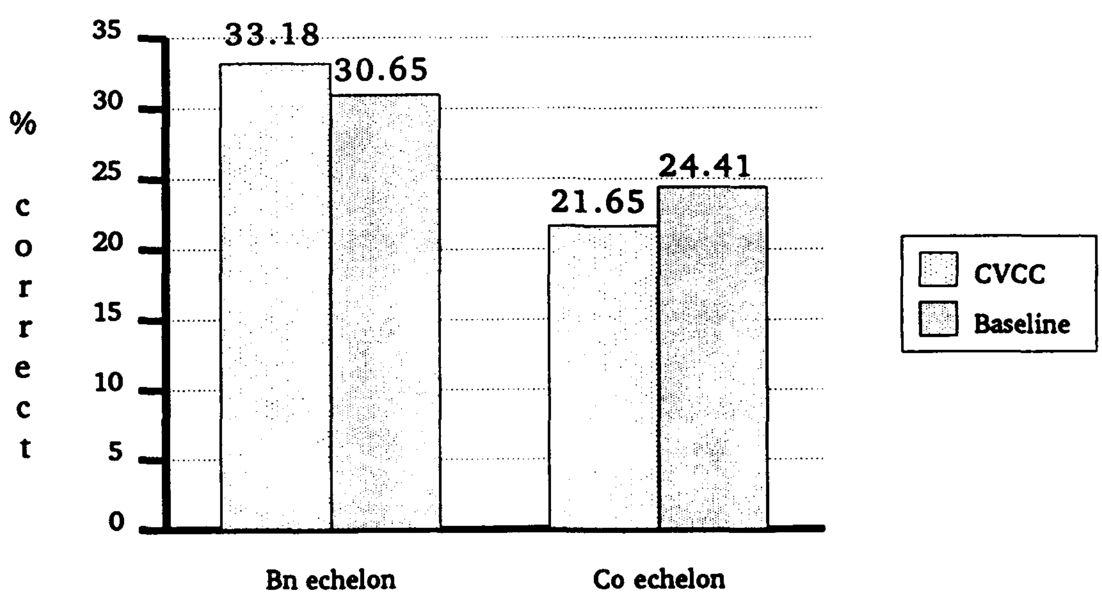

Figure 20. Mean performance for composite situational assessment index.

Composite situational assessment index. The composite situational assessment index used an algorithm that combined each score from the situational assessment questionnaire (see Leibrecht et al., in preparation). The composite score is expressed in terms of percent correct, with possible values ranging from 0 to 100. As shown in Figure 20, the data did not differ notably or consistently between conditions. The remarkably better scores at the battalion echelon may be attributed to a better understanding of the overall situation throughout the battalion.

In analyzing the methods used to assess situational awareness, the approach appeared to be faulty. The assessment itself was an indirect measurement using selected pieces of information that might be considered a byproduct of the participants' tactical awareness. The underlying assumption was that an after-the-fact snapshot of certain kinds of information would facilitate an appraisal of what participants heard, saw, and thought throughout the battle.

The timing of the assessment may have affected the data trend. In order to avoid interrupting the tactical situation, the assessment occurred at the end of the final test stage. By virtue of relatively recent SITREPs and more comprehensive intelligence reports, both Baseline and CVCC units should have had a fairly accurate snapshot of the tactical situation immediately preceding the end of the exercise. It is therefore possible that awareness peaked at these points for all units, without respect to condition. Therefore, if the CVCC system assisted commanders to maintain a more accurate assessment throughout the scenario, the "peaking" effect near the end of the exercise may have reduced the likelihood that such an affect would be captured.

By contrast, the previous findings and discussion regarding the communication of mission, enemy, and friendly information demonstrate how the CVCC system allowed the commander to see the battle more effectively from initial contact to mission completion. Hence, CVCC provided the commander and staff a valuable tool that enabled them to constantly assess the tactical situation. Nevertheless, those apparent advantages did not yield a measurable difference among the measures of situational assessment.

Direct and Lead Subordinate Forces

Hypothesis: The CVCC units' ability to direct and lead subordinate forces on the battlefield was expected to be significantly better than the Baseline units'.

The data collected for this function captured whether the battalion prevented decisive engagement in delay situations, whether it withdrew intact from initial delay positions, whether it massed fires on the OPFOR in the counterattack, and whether

the battalion met the commander's intent. Also, the individual data points for each measure were compiled to form a battalion command effectiveness composite index. As a whole, unit performance was comparable across all conditions and stages. As such, the presentation and discussion of these data is omitted from this report. See Leibrecht et al. (in preparation) for the a comprehensive presentation of data and detailed analysis.

Summary of Command and Control BOS Findings

Table 18 summarizes the results among command and control BOS functions. Overall, the data revealed several meaningful differences between conditions, and highlighted many of the advantages offered by the CVCC system. Most importantly, the CVCC system allowed commanders to see the battlefield more accurately. By reducing the volume of voice traffic, the CVCC system made command nets more accessible. Relative disadvantages of the Baseline condition were demonstrated by the duration and number of transmissions required to disseminate tactical information (e.g., FRAGOs, INTELs, and SITREPs), and the inefficiency related to voice traffic as a result of FRAGO and INTEL consistency measures. Participant comments regarding their overall ability to monitor the battle suggested that CVCC unit commanders were more aware of their subordinate units' status than Baseline unit commanders.

This subsection has focused on C^2 processes. The next subsection addresses the resultant performance in the movement and fires of test battalions.

Maneuver

Issue: Does the CVCC system enhance the Maneuver BOS?

Given the CVCC system's automated navigation and CITV capabilities, the expected impacts on maneuvering and engaging the enemy on the battlefield are substantial. The BOS-based functions and hypotheses supporting the analysis of maneuver performance were introduced earlier in this report. The Data Collection subsection of this report summarized the measures used to quantify performance under these functions. This subsection presents the results of Maneuver-based performance measures. The analysis leads off with techniques and procedures observed or suggested during the evaluation. The performance data presentation and discussion is organized around five maneuver functions: (a) move on surface, (b) navigate, (c) process direct fire targets, (d) engage direct fire targets, and (e) control terrain. The subsection closes with a summary of Maneuver BOS-related findings.

The results for two measures developed under the Maneuver BOS are not presented, because the measures produced nearly all zeros. These measures were "mean time out of sector/axis," and "number of OPFOR vehicles penetrating designated line." Other

Table 18

Summary of Command and Control BOS Findings

Function	Findings
Receive and transmit mission	o More rapid dissemination of FRAGOs using digital format. o Error-free information relayed to subordinates in CVCC, poor consistency in Baseline. o Far less voice traffic and time required to clarify digital FRAGOs.
Receive and transmit enemy information	o Wider dissemination of digital INTEL information. o Digital INTEL reports retained 100% of information
Receive and transmit friendly troop information	o Fewer voice transmissions between battalion commander, S3 and TOC to coordinate battle and analyze new missions in CVCC. o Friendly unit positions constantly displayed; unit status constantly displayed in TOC and immediately available in command tanks in CVCC, as compared to periodic reports in Baseline.
Manage means of communicating information	o Significantly fewer voice radio transmissions, overall, in CVCC. o Marked reduction in the amount of time that radio nets are active with voice traffic. o Notable reduction in the number of named reports sent by voice in CVCC.
Assess situation	o No demonstrated differences.
Direct and lead subordinate forces	o No demonstrated differences.

specific treatments of data were undertaken to explain unexpected trends, as recounted in the results for each maneuver function. The data from several crew-level measures are not recounted in their entirety, in order to focus more on the battalion's overall performance. Previous reports from the CVCC program (e.g., Leibrecht et al., 1992) and Leibrecht et al. (in preparation) present and analyze data regarding crew performance in greater detail.

Maneuver Techniques and Procedures

The following narrative describes techniques and procedures used by commanders and crews in their simulators to navigate and "fight" their individual vehicles, and to control and coordinate the maneuver of their subordinates with that of adjacent elements. For unit and individual vehicle movement, the

discussion focuses on how the CCD was used. For engagement, the focus is on target acquisition, particularly how the CITV was employed.

The CCD could be configured to deselect given map features, such as contour lines and vegetation. The advantage of this was to simplify the display and the processing load on the CVCC computer. If the operator chose to display all map features, the computer would take longer to update the display as the vehicle moved or other data were introduced. Also, a cluttered display was more difficult to interpret. As such, it was generally preferable to disable selected terrain features.

The problem with this procedure was the tendency to ignore the terrain under certain conditions. For example, when the tactical situation changed and units were to move to new locations, the vehicle commander who failed to display all terrain features risked selecting routes and fighting positions that potentially exposed the tank and unit to enemy observation and fires. Thus, it was advisable to display those terrain features when planning movements in close proximity to known or suspected enemy locations, or when establishing battle positions.

Vehicle commanders used various tactical map scales as the situation dictated throughout the scenario. Larger scales (i.e., 1:125,000, 1:250,000) were required to analyze tactical information throughout the battalion area, and to interpret FRAGOs. Smaller scales (i.e., 1:25,000 and 1:50,000) were used to control smaller units (companies and platoons), and to develop tactical routes.

A technique that was used by some commanders to define engagement areas and to facilitate their terrain appreciation was to open a report format (e.g., CONTACT), and then lase to various terrain features to the front. As the range return was processed, the CCD would post a report icon in the corresponding location on the tactical map. The vehicle commander could then verify coverage of the engagement area and any target reference points (TRPs) within his area of operations. Variations of this technique could be used to develop tank range sketch cards, and to coordinate direct fire plans throughout the unit.

The CITV was commonly used in the auto-scan mode. This proved an effective technique under most circumstances, allowing the vehicle commander to search for targets in a hands-off manner. When potential targets appeared, the commander could override the search mode and investigate the possible target, all without interfering with the gunner's search. If the target was hostile, the commander could use the target designate function to slew the turret, then return to auto or manual scan as soon as the gunner identified the target.

In some cases, commanders used the CITV to monitor formations. The advantage of this technique was that the

commander did not have to physically turn around in the cupola to see parts of the unit. The drawback was that a valuable target acquisition tool was turned away from the direction of likely enemy contact. Given that all scenarios were fought under daylight, high visibility conditions, the cupola may have been a better tool for this task. The CCD can also help monitor formations, but it is often difficult to interpret vehicle positions on the CCD, particularly if operating in a larger scale. When considering low visibility operations, it may be desirable to use the CITV for formation monitoring and position-keeping among selected tanks in a unit.

Many of the CVCC participants expressed concern over the degree to which their attention was drawn inside the turret by the CVCC system, particularly early in the training process. Both the CITV and the CCD require the vehicle commander to look away from the vision blocks. This frequently generated fear that dangerous targets would appear and not be detected because the commander did not have his head up. As they became more familiar with the system, vehicle commanders developed a routine to attend to the vision blocks, CITV and CCD periodically. As confidence in the CCD and the CITV grew, and participants refined their routine, they became more comfortable with the overall system. A key lesson learned, however, is in the absence of a "heads-up" adaptation of the CVCC system (i.e., a helmet-mounted display), an effective scan routine would be an essential usage technique.

Move on Surface

Hypothesis: The CVCC units' ability to move on the surface of the battlefield was expected to be significantly better than the Baseline units'.

Generally, CVCC unit performance was better than Baseline units' among four of the five measures supporting this function. CVCC units maintained greater stand-off from OPFOR units over all stages, as measured at the moment that the unit began to maneuver in both delay stages, and at the end of all stages. CVCC units crossed the LD closer to the scripted time, and reached the objective more quickly than Baseline units during the counterattack. Overall, these findings suggest that CVCC units were more agile than Baseline units.

Distance between BLUFOR and OPFOR center of mass (CoM). Originally designed for delay missions (Stages 1 and 3), this measure was defined to quantify the battalion's success in preventing the enemy force from closing on them during the delay. Subsequently the measure was extended to the offensive mission (Stage 2), since that mission ended with a defense of the newly occupied objectives. The distance between each BLUFOR non-reserve company's CoM and the CoM of its nearest OPFOR company was computed at the point when the last OPFOR firing occurred. The average of the three non-reserve companies' values was

computed to yield a battalion-level measure. Larger values signified better unit performance.

Data for this measure are displayed in Figure 21. In all three stages, the average end-of-engagement distance separating BLUFOR and OPFOR companies was significantly greater in the CVCC condition than in the Baseline condition. Differences between stages resulted from the tactical differences built into the test scenario. That is, in Stages 1 and 3, the intent was to establish contact, engage with direct and indirect fires, and maintain an effective stand-off range to retain freedom of maneuver and not be decisively engaged during the delay. In the counterattack, the intent was to close with and destroy the OPFOR, and hence, shorter engagement ranges were expected.

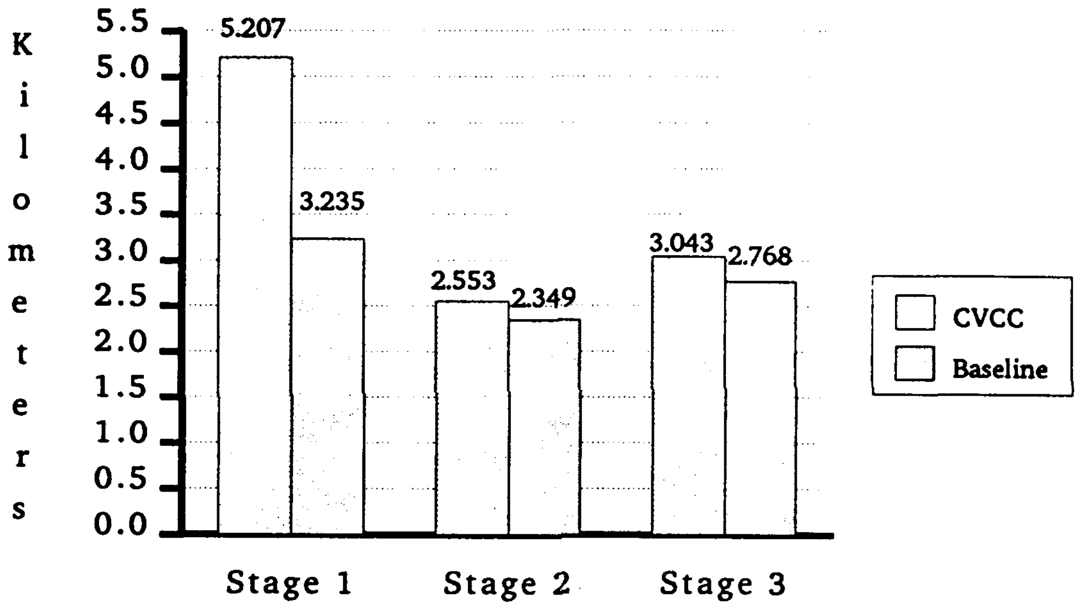

Figure 21. Mean distance between OPFOR and BLUFOR center of mass at end-stage.

The distances indicated in Stage 1 suggest that most companies had broken contact by the time the last engagement occurred. The difference can only be seen as an advantage for CVCC when taken in the overall context of the scenario. Given the degree of OPFOR destruction achieved by most units prior to the end of the stage (see Table 21), and the need to rearm prior to the counterattack, these distances are reasonable. CVCC units were able to disengage more of their force, and were prepared to execute sustainment operations further away from the action--thus better protecting the (notional) CSS assets as well as the units being resupplied.

In the counterattack, the results must be cross-referenced with OPFOR losses, and with the amount of time to accomplish that function (i.e., time to complete Stage) to ensure that the primary function--enemy destruction--is accomplished rapidly.

The greater range among CVCC units, which also destroyed a greater portion of the enemy formation and completed the mission more rapidly, does sustain the finding that CVCC units performed better than their Baseline counterparts.

Time to reach line of departure (Stage 2 only). The counterattack FRAGO established an LD time 15 minutes after the start of the Stage. These data were computed as the time elapsed from the start of the stage (STARTEX) to the point when the first vehicle crossed the LD. Although not defined as a separate measure, the amount of time for the battalion to report REDCON-1 was also recorded.

Within that 15 minute time frame, the battalion was expected to disseminate the FRAGO and move to the LD. In all cases, A Company had the furthest travel distance to the LD: approximately 6.5 km. In Baseline units, this often meant that A Company had to begin moving before the order was completely relayed to the platoon leaders. Units reported REDCON-1 when all elements had received the order and were on the move or ready to move. Because of differences in orders transmission media between conditions, and variations in how units in both conditions processed the FRAGO, REDCON-1 times varied among units. Some units did not formally report REDCON-1.

Among those units that reported REDCON-1, CVCC units took significantly less time to do so: an average of 9.48 minutes as compared to an average of 17.28 minutes among Baseline units (see Table 19). This clearly demonstrates an advantage for orders processing among CVCC units, as previously indicated under the Command and Control BOS.

LD crossing times are also shown in Table 19. CVCC units crossed the LD, on average, 19.43 minutes into the stage (range: 13.3 to 24.0 minutes), as opposed to 24.84 minutes, on average (range: 16.37 to 31.6 minutes), for Baseline units. When expressed as a deviation from the target time, CVCC units averaged 4.43 minutes late and ranged from 1.7 minutes early to 9 minutes late. Using the same criterion, Baseline units ranged from 1.37 minutes to 16.6 minutes late, and averaged 9.84 minutes late. This trend also shows a clear advantage among CVCC units.

Time for companies to reach objectives (Stage 2 only). This measure quantified the time to reach the objective during the counterattack, for all non-reserve companies. The time was measured from the start of the stage until each company (A, B, and C) reached the objective. The times were averaged to arrive at a single value per test unit. The data are presented in Table 19.

CVCC units arrived an average of seven minutes sooner than Baseline units. This represents a significant difference between CVCC and Baseline. When combined with the previous measure, CVCC

Table 19

Critical Times During Counterattack (in Minutes, from STARTEX)

Measure	CVCC	Baseline
REDCON-1 time (Target: ASAP)		
Earliest	3.083	13.533
Average	7.825	17.279
Latest	12.483	23.917
	_n_=5	_n_=4
LD time (Target: 15.0)		
Earliest	13.3	16.367
Average	19.433	24.844
Latest	24.0	31.6
	_n_=6	_n_=6
Arrived on Objective (Target: ASAP)		
Earliest	23.872	29.817
Average	29.424	36.349
Latest	36.383	45.089
	_n_=6	_n_=6

units took an average of ten minutes to move from the LD to the objective, as compared to 11.5 minutes in Baseline units.

Range to OPFOR at displacement (Stages 1 and 3 only). The displacement criterion for the delay mission was when a company-sized OPFOR element approached within 2000 m of a BLUFOR company's position (see Appendix C, OPORD 200). This measure was designed to quantify how well the company commanders were able to apply this criterion in requesting/executing their unit displacement. The linear distance between each BLUFOR non-reserve company's CoM and its nearest OPFOR company's CoM was computed at the time the battalion displacement began, then was averaged across companies. For the conditions of this evaluation, longer distances generally corresponded to better performance.

In both delay stages, the average displacement ranges were greater for CVCC-equipped companies. The average range among CVCC units was 2836.5 m (standard deviation (SD) = 564.4) in Stage 1 and 2364.8 m (SD = 404.9) in Stage 3. The average range in Stage 1 among Baseline units was 2607.2 m (SD = 392.6), and in Stage 3 was 2251.0 m (SD = 451.9). However, these data do not represent a significant difference between CVCC and Baseline. Units in both conditions began the displacement at a greater

range in Stage 1 than in Stage 3, due to the availability of better long range fields of fire in the first stage.

The reader will note that, in all cases, the average ranges exceeded the 2000 meter disengagement criterion. This is explained by the measures' definition, in that the data were collected when the battalion began the delay, rather than taking individual measurements for each company as it began to maneuver. These data do not clearly indicate the range to the OPFOR from the BLUFOR company that keyed the disengagement, so it is difficult to determine whether the displacement criterion was met. However, by referring to other measures, the reader can make a judgement regarding the underlying precept: that of avoiding decisive engagement.

Overall, CVCC units achieved a more advantageous loss/kill ratio and retained more of their own combat power than did Baseline units in Stage 1 (see Table 21). More OPFOR losses were inflicted by Baseline units, but at a higher proportionate cost in terms of own losses. Units in both conditions effectively stopped the OPFOR advance in Stage 1. In Stage 3, however, the data trend leaned the opposite direction. Although CVCC units began the delay in Stage 3 with the OPFOR at a greater range, they sustained more losses and inflicted less damage on the enemy. In summary, while an apparent trend is indicated by the mean range to the OPFOR at the time of displacement, the data are not conclusive.

Exposure index. The exposure index was developed to quantify a vehicle's risk of enemy-initiated engagement. Following initial intervisibility with an enemy vehicle, a count of all intervisible enemy vehicles was obtained for each manned vehicle every 30 seconds until the first main gun firing by that company, or either the battalion commander or S3, in the case of the command group. All counts from the sample period were averaged to yield a single value per manned vehicle. For this measure, smaller values were desirable. In effect, this measure was designed to determine the degree to which command group vehicle crews used cover and concealment up to the point that the unit was engaged. Direct fire periods were excluded from the data collection window to avoid contaminating the data with those periods during which the vehicle crew risks being engaged specifically for the purpose of returning fire on the enemy.

There were no consistent differences between the CVCC and Baseline conditions. In Stage 1, Baseline units had higher indices than CVCC units, but the trend was reversed in Stage 3. In the counterattack, CVCC battalion command groups were more exposed than Baseline battalion command group vehicles, whereas CVCC company commanders and XOs were less exposed than their counterparts. Units in both conditions were exposed more often in the delay stages than in the counterattack, due to the difference in force ratios throughout the stages.

An unexpected effect was that the exposure index for battalion command group members in both conditions and all stages was higher than for company echelon vehicles. This may be attributed in part to the averaging affect across company echelon vehicles, as opposed to the battalion command groups' desire to move to the action. That is, if one company out of three was in contact, then only two of the six company command tanks might have been exposed, whereas the battalion commander and S3 might move to that action and in so doing, expose themselves to enemy observation. Alternatively, battalion commanders and S3s in CVCC may have held their fire longer once in line-of-sight contact. This would have had the effect of accumulating more exposure time until either member of the command group opened fire.

<u>Summary</u>. Three of the five measures within this function showed a substantial difference between CVCC and Baseline units: the distance between OPFOR and BLUFOR company centers of mass at end stage, the time to reach the LD, and the time to reach the objective in the counterattack. Also, REDCON-1 times in Stage 2 show a clear advantage for CVCC units. Otherwise, the data trends among the remaining measures suggest an advantage for CVCC units, but the differences shown between CVCC and Baseline are too small to be considered reliable. The trends favoring CVCC unit performance are consistent with findings in prior efforts, and support the hypothesis that CVCC units moved more effectively than Baseline units.

<u>Navigate</u>

Hypothesis: The CVCC unit's ability to navigate on the battlefield was expected to be significantly better than the Baseline units'.

Only one measure supporting this hypothesis (time to complete stage) produced data that show a clear advantage among CVCC units. The other two measures, distance travelled and fuel used, yielded data that did not demonstrate discernable differences between conditions.

<u>Distance travelled and fuel used</u>. These measures report the actual distance travelled and fuel consumption among manned vehicles during each stage. Because of the direct relationship between distance travelled and fuel used, the findings are grouped together for analysis and discussion. Because of the CVCC's automated navigation capabilities, it was anticipated that CVCC-equipped battalions would be able to navigate more accurately and avoid being lost or misoriented. Accordingly, crews in the CVCC condition were expected to travel less distance, overall, in accomplishing the mission. As a result of the expectation that the CVCC capabilities would reduce overall distance travelled, it was anticipated that fuel consumption would also decline.

As shown in Table 20, CVCC units did not perform as expected in the delay stages. CVCC units travelled further and consumed more fuel than Baseline units in delay stages. In the counterattack, distance travelled and fuel used was slightly lower in CVCC units.

Table 20

Mean Performance Data for Navigate Hypothesis

	Stage 1		Stage 2		Stage 3	
Measure	CVCC	Baseline	CVCC	Baseline	CVCC	Baseline
Distance travelled (meters)						
Bn Echelon	13517.8	13512.3	7455.6	8509.5	8006.0	6550.5
	(7352.1)	(8171.9)	(3341.9)	(3114.2)	(2585.3)	(2394.8)
	n=11	*n*=12	*n*=11	*n*=12	*n*=10	*n*=8
Co Echelon	13378.9	11270.2	9597.2	10044.0	9037.3	7525.5
	(5083.2)	(4062.7)	(2521.8)	(2823.8)	(3242.2)	(2514.2)
	n=36	*n*=36	*n*=35	*n*=36	*n*=30	*n*=23
Fuel used (gallons)						
Bn Echelon	20.74	22.91	12.63	16.29	14.87	12.64
	(8.23)	(10.90)	(3.78)	(4.74)	(3.09)	(3.11)
	n=11	*n*=12	*n*=11	*n*=12	*n*=10	*n*=8
Co Echelon	20.22	18.99	17.53	16.18	15.04	12.29
	(6.89)	(5.77)	(8.92)	(4.84)	(5.09)	(3.68)
	n=36	*n*=36	*n*=35	*n*=36	*n*=30	*n*=23

Note. Standard deviations appear in parentheses below the means.

The differences between conditions in both delay stages can be attributed, in part, to the greater degree of agility demonstrated by CVCC units. Overall, CVCC units maneuvered in greater depth within the battalion's area of operations during the delay. Thus, CVCC units took advantage of the CVCC system's navigational aids to operate in a more fluid and tactically sound fashion than Baseline units. Whereas Baseline crews generally used direct routes to move to subsequent positions, CVCC units could use the terrain more effectively to maintain cover and concealment, without becoming misoriented. Another factor may have been the degree to which participants in the battalion evaluation operated in conjunction with their subordinate SAFOR elements, and the degree of maneuver freedom afforded the battalion commander in the scenarios. Command crews in CVCC were able to operate more confidently on their own, independent of their subordinate (SAFOR) platoons, and as a result moved about the battlefield more often to observe from different vantage points. In the company level evaluation, test units were allowed less flexibility to maneuver laterally and in depth. Leibrecht et al. (1992) reported that CVCC units, given those tactical constraints, travelled less distance and consumed less fuel while

accomplishing the same tasks as Baseline units (e.g., moving to specified BPs, checkpoints, and objectives).

The distance travelled and fuel used measures were originally intended to quantify any movement resulting from a crew becoming lost or misoriented within the battalion's boundaries. Another measure, "mean time out of sector/axis," was also intended to capture such events. Although the measures themselves did not successfully identify lost vehicle cases, control personnel observed crews that became separated from their subordinate elements in both conditions. Those observations indicated that the performance of individual tanks differed consistently between conditions. Among CVCC units, separated crews moved rapidly to rejoin their units once they realized that they had been "left behind." Once on the move, CVCC crews typically kept rolling until they had rejoined the unit. Baseline crews typically did not waste much time starting the move, but their movements were more deliberate. They were more likely to follow roads, trails, or other linear objects, and they often stopped at various points to verify their location and reorient for the next leg of their move. As a result, separated or misoriented Baseline crews generally took longer than CVCC crews to rejoin their parent unit. Finally, misoriented Baseline crews occasionally linked up with adjacent elements rather than their own.

<u>Time to complete stage</u>. The time required to fully execute each stage was defined as the elapsed time from the start of the stage to the completion of the last scripted event (submission of a SITREP). This measure is defined under navigation due to the large degree to which maneuver contributed to meeting end-stage criteria. In every stage, the battalion was expected to move to or through a given set of terrain-based battle positions or objectives, as well as fight a tactical engagement. Given the CVCC's automated C^3 capabilities, CVCC-equipped battalions were expected to perform each mission more quickly than Baseline battalions.

The data for time to complete each stage are represented graphically in Figure 22. Stage 3 data were excluded from the analysis due to the fact that several battalions were not able to complete the stage. Overall, battalions using the CVCC system took significantly less time for mission completion. The different times between stages correspond with scripted scenario times as indicated in the preceding discussion on the Command and Control BOS.

The faster completion times for CVCC-equipped battalions overall are congruent with the data for time to reach LD and time to reach the objectives (discussed earlier under the Move on Surface hypothesis). This trend replicates previous findings reported by Leibrecht et al. (1992).

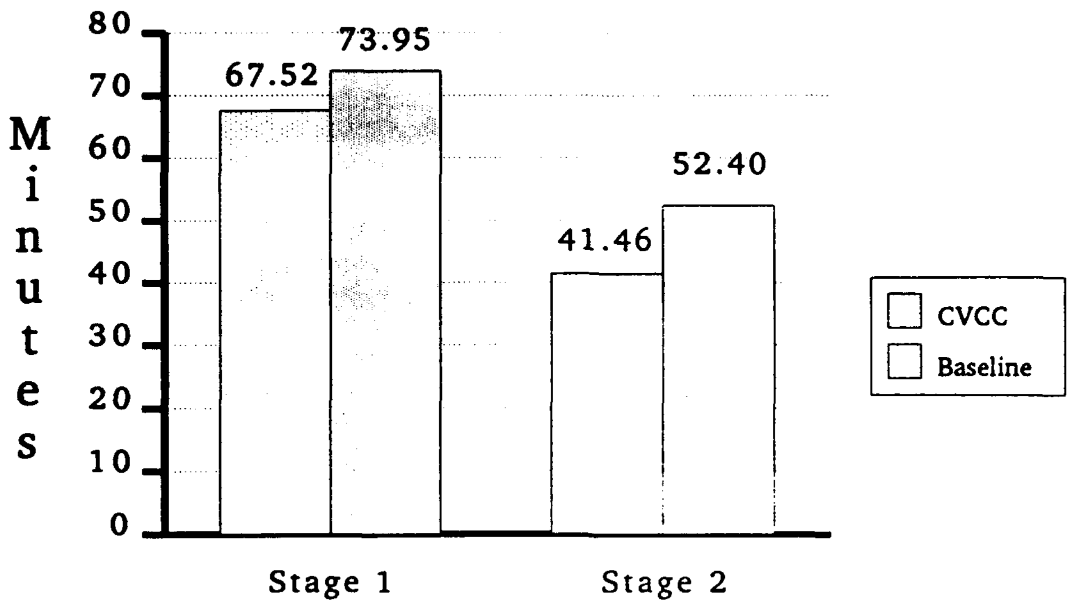

Figure 22. Mean time to complete stage.

Summary. The greater agility demonstrated by CVCC crews in the distance travelled and fuel used measures, and the faster completion times demonstrate an advantage of the CVCC system. Although the differences among all measures are not significant, and do not support the hypothesis as originally stated or intended, the results do suggest better navigation performance in general, particularly when considered in conjunction with the findings of previous evaluations.

Process Direct Fire Targets

Hypothesis: The CVCC units' ability to process direct fire targets on the battlefield was expected to be significantly better than the Baseline units'.

This hypothesis relied entirely on the performance of individual crews. Previous CVCC and CITV evaluations demonstrated significant performance differentials in favor of CITV-equipped crews (Leibrecht et al., 1992; Quinkert, 1990). However, in those prior efforts, a higher percentage of the soldier-participants were operating in crews at the platoon level and below, where crew gunnery performance is a critical factor. In the battalion evaluation, all crews manned command tanks at the company level and higher. The immediate issue of concern was whether C^2 duties at the company and battalion echelon reduced the potential contribution provided through the combination of the CITV (i.e., the hunter-killer capability) and the CCD (i.e., shared enemy information) at the crew level. Because these measures are concerned with crew level performance, only a summary of findings is provided for some of these measures. A detailed presentation and analysis of data may be found in Leibrecht et al. (in preparation).

Overall, CVCC units acquired targets significantly sooner and at greater ranges than did Baseline units. The times between lases to different targets showed no discernible difference. Times from first lase to first fire seemed to show a slight advantage in favor of the Baseline condition. Also, CVCC units had a higher incidence of fratricide events.

Maximum lase range. This measure was designed to quantify the outer edge of the range envelope for detecting potential targets. It was defined as the maximum distance a manned vehicle lased to a potential target, per stage, excluding lasing to non-vehicles. In the CVCC condition, both GPS and CITV lase events were eligible. Given the CITV capabilities to enhance battlefield surveillance and target acquisition, CVCC-equipped vehicles were expected to generate greater maximum lase ranges. Mean maximum lase ranges are illustrated in Figure 23. Overall, the mean ranges for CVCC-equipped vehicles were significantly greater than those for Baseline vehicles.

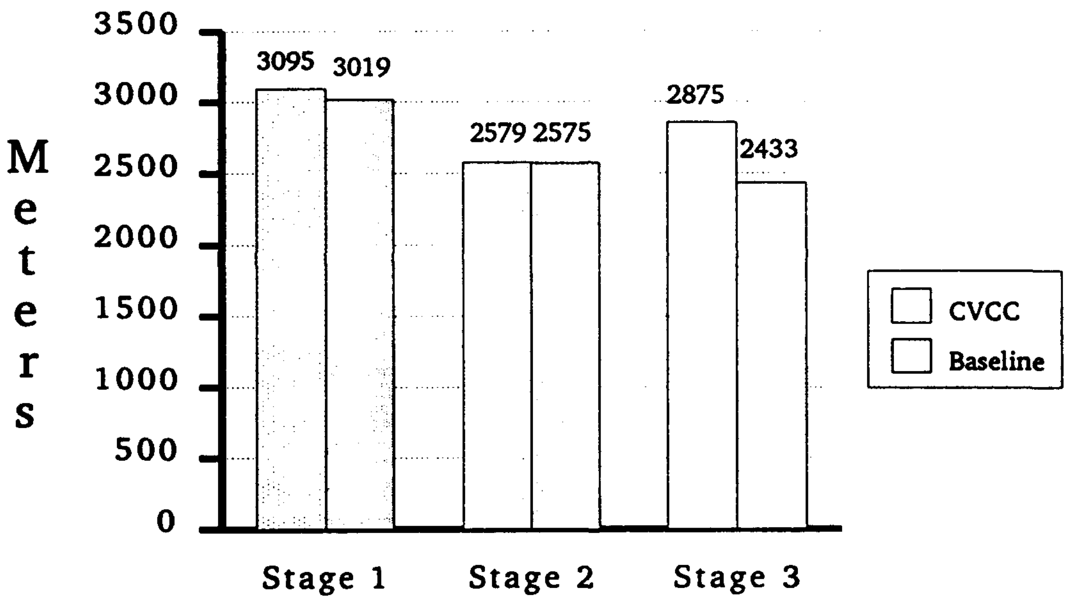

Figure 23. Mean maximum lase range.

Time to acquire targets. Target acquisition time was quantified by measuring, for each manned vehicle, the elapsed time between initial visibility of an enemy vehicle and the first lase to the same vehicle. For CVCC-equipped vehicles, lases by the commander and the gunner were compared to select the shorter interval. For each stage, the average per vehicle was computed. Because of the CVCC's independent thermal viewing capabilities for unit and vehicle commanders, crews were expected to acquire targets more quickly in the CVCC condition.

Figure 24 shows times to acquire by condition and mission (i.e., delay and counterattack). Across all Stages, CVCC units acquired targets sooner than Baseline units. The difference

averaged 20 seconds in Stage 1 and 26 seconds in Stage 3 (24 seconds, on average, for delay situations). Since CVCC crews generally acquired beyond effective main gun range (i.e., 2500 meters in MWTB), this allowed them more time to initiate the engagement with indirect fires before opening with direct fires. In the counterattack, the difference between conditions is much more notable, averaging approximately 43 seconds.

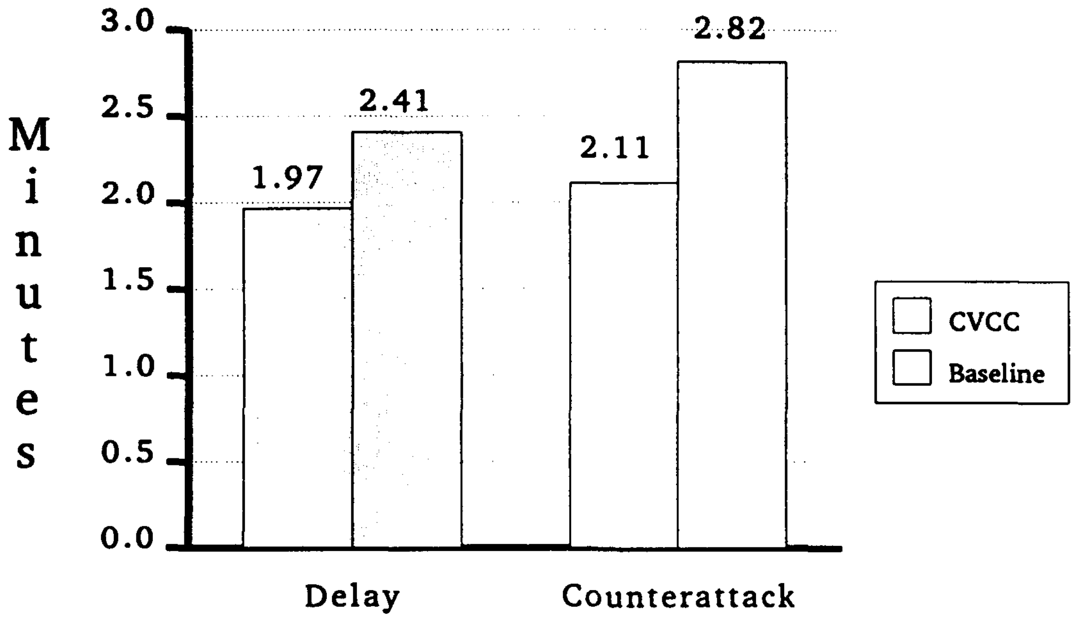

Figure 24. Mean time to acquire targets.

Both this and the preceding measure suggest that the CVCC unit commander is not so burdened with C^2 tasks (i.e., drawn to the CCD) that he cannot contribute substantially to target acquisition.

<u>Time between lases to different targets</u>. As an index of speed in acquiring sequential targets, this measure quantified the time interval separating successive lases to different enemy vehicles. The computational procedure measured the elapsed time from a manned vehicle's last lase at an OPFOR vehicle to its first lase at the next OPFOR vehicle. The advantage of sighting/lasing systems for both the commander and gunner (the "hunter-killer" capability) led to the expectation of shorter values for this measure among CVCC-equipped vehicles.

The mean values for this measure did not vary greatly across conditions. The reader should be aware that, given the independent laser in the CITV and the ability to use the CITV's LRF to input enemy locations in tactical reports on the CCD, not every lase event was directly related to a direct fire engagement. It is possible that using the CITV's laser for report input may have affected this measure in an unpredicted manner.

Time from first lase to first fire. This measure was designed to provide an index of a crew's speed in responding to enemy targets with direct fire. Conceptually, the process included application of IFF procedures. In practice, elapsed time was computed from a manned vehicle's first lase at an enemy vehicle to the firing of the first round directed at the same vehicle. Given the enhanced situational awareness expected to result from CVCC capabilities (e.g., greater awareness of friendly and enemy positions), shorter lase-to-fire times were anticipated for CVCC-equipped vehicles. Performance data from this measure are presented graphically in Figure 25.

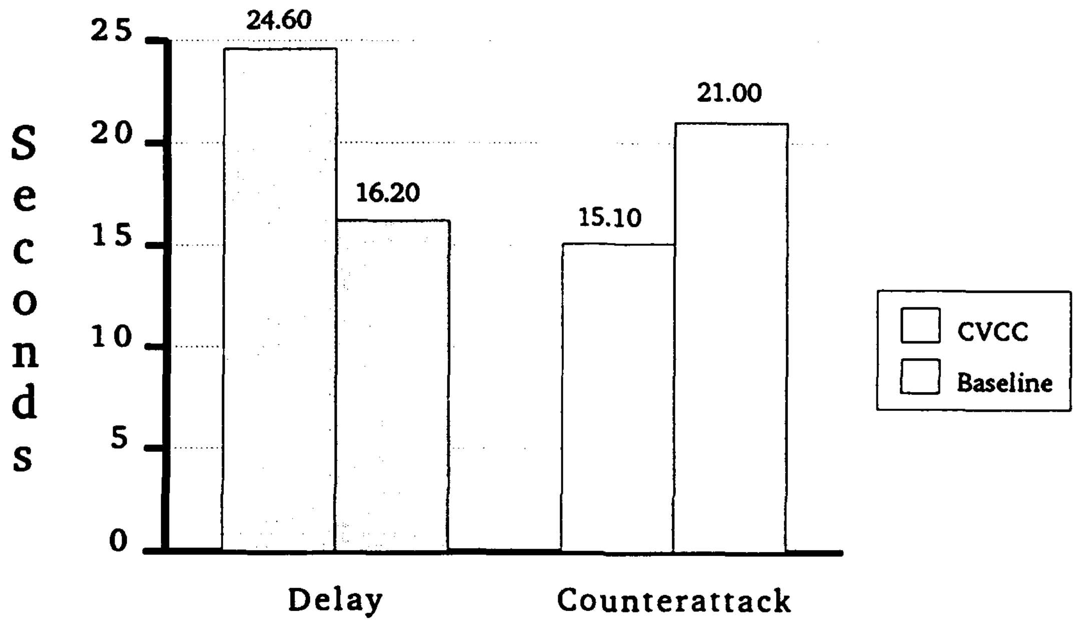

Figure 25. Mean time from first lase to first fire.

During the delay stages, Baseline units appear to enjoy an eight second advantage over CVCC units, on average. By contrast, during the counterattack, CVCC units' lase-fire times were an average of six seconds shorter than Baseline units'. At first glance, these data suggest slower reaction times in the delay among CVCC units. However, when considering the data presented earlier (i.e., earlier acquisition by CVCC units), the slower lase to fire times become less alarming. That is, the initial acquisition could result in longer average lase-to-fire times as CVCC units waited until the OPFOR formation closed within effective direct fire range. As with the previous measure, the difference in the delay may be attributed, in part, to the independent LRF on the CITV.

Number of fratricide hits and kills by manned vehicles. IFF was an important element of the process direct fire targets hypothesis. The IFF system built into the CITV and the graphic display of own unit locations on the CCD were expected to help prevent fratricide events among CVCC units.

Fratricide events were infrequent over the course of the scenarios, and the low number of events overall make it difficult to attribute their occurrence to other than random factors. Nevertheless, it is clear that those incidents occurred more frequently in CVCC units, as shown in Figure 26.

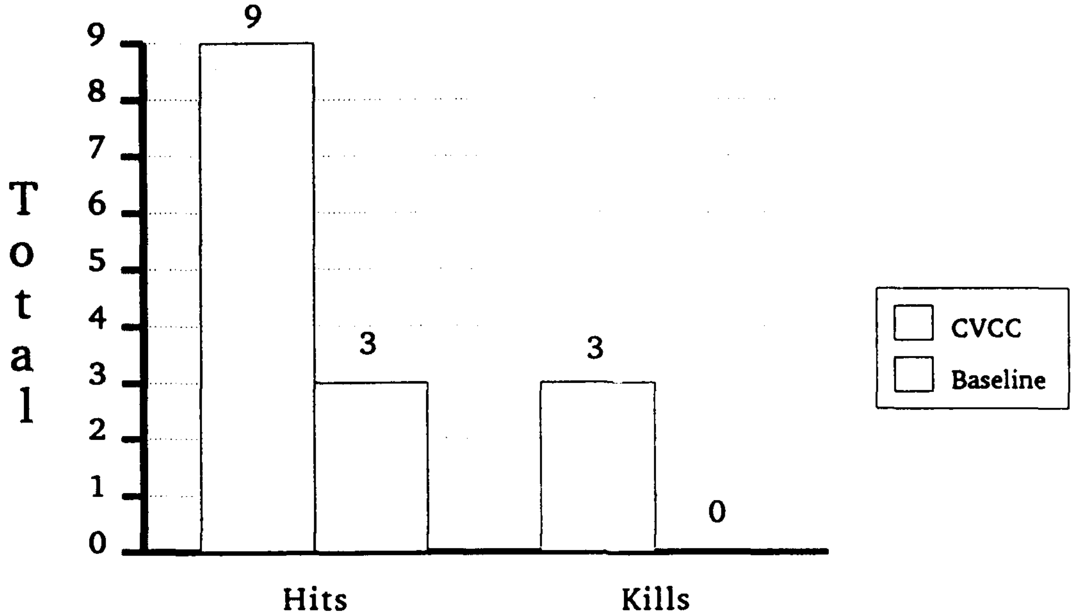

Figure 26. Total number of fratricide events, by condition.

Many of the fratricide events were observed by control personnel and investigated in detail during scenario debriefings (Meade et al., in preparation). According to the crews, most of those that occurred in CVCC units were attributed to faulty target identifications made by the gunner when the vehicle commander was preoccupied with command and control tasks. Vehicle commanders reported using the CITV to obtain an IFF readout in only a few of the observed fratracide cases, but the system provided either enemy or indeterminate identifications. In those situations, vehicle commanders attempted to visually confirm the target through the GPSE, but were unable to recognize the vehicle as friendly (Meade et al., in preparation).

In cases where the gunner was operating independently of the vehicle commander, the CVCC system provided no direct advantage over Baseline. Differences in the relative deployment of CVCC units may have resulted in more opportunities to engage adjacent friendly elements. Alternatively, the higher experience levels among Baseline gunners, combined with the higher volume of voice position reports associated with the Baseline condition may have favorably influenced Baseline unit performance. Finally, the availability of the IFF system may have provided a false sense of security among CVCC crews, despite warnings of its expected error rate.

Summary. The significantly faster acquisition times and greater maximum range returns for CVCC units support the hypothesis of better target processing performance using the CVCC system. However, the degree of advantage attributable to the CVCC system in this evaluation is not as great as the performance differential documented in prior efforts. Otherwise, the lack of notable differences among the remainder of the measures may be attributed to the degree to which vehicle commanders are distracted by command and control duties in both conditions. In view of the better target processing performance among crews during previous evaluations (Quinkert, 1990, Leibrecht et al., 1992), the findings in the current effort show that the CCD does not distract a unit commander any more than conventional C^2 methods at the company and battalion levels. The higher incidence of fratricide among CVCC crews, although not a statistically significant finding, is alarming, and bears further study.

Engage Direct Fire Targets

Hypothesis: The CVCC units' ability to engage direct fire targets on the battlefield was expected to be significantly better than the Baseline units'.

The measures supporting this hypothesis contain data taken from the entire unit as well as manned vehicles only. Vehicle kill data (both enemy and friendly) include both catastrophic and firepower kills (as determined on-line by the vehicle's computer), but not mobility kills. In order to demonstrate the units' overall effectiveness, kills due to both direct and indirect fire are counted among unit-level performance measures, unless otherwise noted. Finally, friendly damages and casualties include those resulting from friendly fire (i.e., fratricide).

Many of the measures supporting this hypothesis demonstrated better performance among CVCC units, although the differences between conditions were relatively small. CVCC crews did achieve a notably higher kill per hit ratio than did Baseline units, and a more advantageous loss to kill ratio in Stages 1 and 2. CVCC units also retained a greater proportion of their own force during the counterattack (Stage 2). Two measures showed trends favoring Baseline units, specifically: percent of OPFOR killed per stage, and the number of hits per rounds fired by manned vehicles. Negligible differences between conditions appeared for the number of rounds fired by manned vehicles. Table 21 contains summary data (means and standard deviations) for selected measures supporting this hypothesis.

Percent of OPFOR killed by end of stage. This primary indicator of engagement outcome quantified the battalion's success in destroying the enemy forces. As shown in Table 21, the data for this measure differed sharply between the counterattack and delay stages, due to the difference between the missions. The difference between conditions in Stage 1 is

Table 21

Mean Performance Data for Engage Direct Fire Targets Hypothesis

Measure	Stage 1 CVCC	Stage 1 Baseline	Stage 2 CVCC	Stage 2 Baseline	Stage 3 CVCC	Stage 3 Baseline
Percent OPFOR killed	87.1 (8.7) n=6	88.2 (8.6) n=6	98.1 (1.6) n=6	91.1 (13.4) n=6	71.9 (21.8) n=5	87.2 (17.9) n=4
Percent BLUFOR killed	22.1 (10.0) n=6	26.0 (10.7) n=6	4.4 (2.3) n=6	9.4 (6.0) n=6	26.6 (9.7) n=5	22.3 (10.7) n=4
Losses/kill ratio	0.16 (0.08) n=6	0.19 (0.10) n=6	0.05 (0.02) n=6	0.12 (0.09) n=6	0.28 (0.13) n=5	0.18 (0.11) n=4
Percent OPFOR vehicles killed by manned vehicles	10.1 (6.5) n=6	10.4 (3.7) n=6	6.6 (2.9) n=6	3.8 (2.7) n=6	14.0 (6.5) n=5	12.6 (7.1) n=4
Number of manned vehicles sustaining a killing hit	2.17 (1.94) n=6	2.33 (0.82) n=6	0.67 (0.82) n=6	0.83 (0.98) n=6	2.40 (1.52) n=5	3.25 (1.89) n=4
Number of rounds fired by manned vehicles						
Bn Echelon	11.6 (10.3) n=11	10.0 (6.5) n=12	4.1 (5.9) n=11	5.2 (6.8) n=12	6.5 (7.2) n=10	8.8 (10.5) n=8
Co Echelon	15.4 (7.5) n=36	15.1 (10.8) n=36	8.0 (9.0) n=36	8.1 (8.6) n=36	10.5 (6.6) n=30	12.1 (8.8) n=24

Note. Standard deviations appear in parenthesis below the means.

negligible (less than two OPFOR vehicles, on average). In Stage 2, CVCC units turned in a slightly better performance than Baseline units, but the difference was again relatively small (less than five vehicles).

In Stage 3, the difference was more notable, representing an average of 15 more kills per stage by Baseline units. This difference is probably due to differences in the way that unit commanders positioned their forces at the start of the stage. It may also suggest that CVCC unit commanders were more constrained by the graphic control measures that appeared on their CCDs with the FRAGO that began Stage 3. Baseline commanders were given only the center of mass of the assigned battle position, whereas CVCC commanders received the digital overlay with the BPs. By conforming to the BP as drawn on the overlay, CVCC commanders established platoon fighting positions that were less suitable to engaging the enemy at longer ranges than those selected by

Baseline commanders. CVCC company commanders were not routinely encouraged to reposition platoons and coordinate adjusted platoon BPs with the battalion commander or TOC at the start of Stage 3. The overlay was therefore more restrictive than the verbal FRAGO. In retrospect, it would have been advisable to use less restrictive graphics in the CVCC overlay, and to direct unit leaders to find hasty defensive positions that would optimize engagement ranges.

Percent of BLUFOR killed by end of stage. This measure was used to evaluate whether the battalion successfully "protected its forces." The entire BLUFOR (manned and unmanned) was included in these data. The data are shown in Table 21.

Overall, CVCC units were slightly more successful at sustaining their combat power than Baseline units. In Stage 2, the smaller mean value and the smaller standard deviation among CVCC units are notable: Baseline unit losses were, on average, nearly double those suffered by CVCC groups in the counterattack. Losses in the delay stages averaged between 22 and 27 percent of the BLUFOR, and were not consistent between units. The data for Stages 1 and 3 essentially cancelled each other out, such that only a negligible difference (i.e., less than 0.4%) remains, overall, in delay situations.

Losses/kill ratio. The losses/kill ratio provides information about a units' combat effectiveness, and was calculated by dividing the total number of BLUFOR losses by the total number of OPFOR losses. It is similar to a loss-exchange ratio.

In both Stages 1 and 2, CVCC units achieved a more advantageous ratio than did Baseline units. These data are more easily interpreted using the reciprocal of the decimal fractions shown in the table. In Stage 1, CVCC units averaged 6.25 kills per BLUFOR vehicle lost, as compared to 5.26:1 in Baseline. In Stage 3, the data favor the Baseline (5.56:1) over CVCC units (3.57:1). The most notable difference occurred in the counterattack. In Stage 2, CVCC units averaged 20 OPFOR vehicle kills per loss, while Baseline units averaged 8.33:1. When the Stage 2 data are analyzed in isolation, a clear advantage is indicated for the CVCC system.

Percent of OPFOR vehicles killed by all manned vehicles. This measure provides an indication of the degree to which participant crews contributed to the OPFOR's destruction during the scenario. It was calculated by determining the number of OPFOR vehicles killed by manned vehicles, and dividing by the total number of OPFOR vehicles killed.

Overall, CVCC units claimed a slightly larger proportion of total kills than did Baseline units. The greatest differential between conditions appeared in the counterattack. This affect may be a result of both navigation and C^2 performance: In

Baseline units, company commanders and XOs were required to both navigate and control the movement of their units in coordination with adjacent units, as well as search for targets. In CVCC, the automated navigation function simplified individual tank movement, while the CCD simplified coordination tasks. This allowed the vehicle commander more opportunities to search for targets and to initiate the engagement more quickly once in contact.

Number of manned vehicles sustaining a killing hit. Even though manned simulators were programmed to override the damaging effects of direct and indirect fire hits, the host computer classified hits in terms of damages sustained. The number of vehicles sustaining at least one killing hit was tallied during each stage to include fratricide events. This measure provided a rough indicator of exposure to lethal fires.

The data for this measure appear in Table 21. Although consistently fewer manned tanks in the CVCC condition sustained killing hits, the difference was negligible. The data for this measure are consistent with the fact that Baseline units tended to fight at closer ranges to the OPFOR, and were therefore more susceptible to taking losses. In all but the last stage, these data correspond to those regarding BLUFOR losses as a whole.

Mean target hit range. This measure was designed to capture the average distance at which crews firing their main guns scored hits against enemy targets. Applied to manned vehicles only, the measure was computed as the distance (in meters) from a firing vehicle to the OPFOR vehicle hit by the round fired (i.e., fratricide hits were excluded). The range values for all hits scored by a given crew were averaged to produce a single value per vehicle, per stage. Given the hunter-killer advantage of the CITV, CVCC-equipped battalions were expected, on the average, to hit targets at greater ranges. As shown in Figure 27, the data showed a small apparent advantage among CVCC units in delay stages, and slightly greater hit ranges for Baseline units in the counterattack stage.

Mean target kill range. This measure was defined and computed very similarly to the preceding measure (mean target hit range), the only difference being whether the result was classified as a kill. The data for this measure (see Figure 28) show an advantage of slightly more than 100 meters, on average, among CVCC units in all three stages.

Due to the small differences between conditions and variability of the data, the values for mean target hit and kill ranges must be considered comparable. This may be attributed to the limitations of the equipment used for the evaluation. Given that the gunner's fire control system did not differ between conditions, any apparent advantage accorded CVCC crews by longer acquisition ranges may have been negated by the technological limitations found in the MWTB environment.

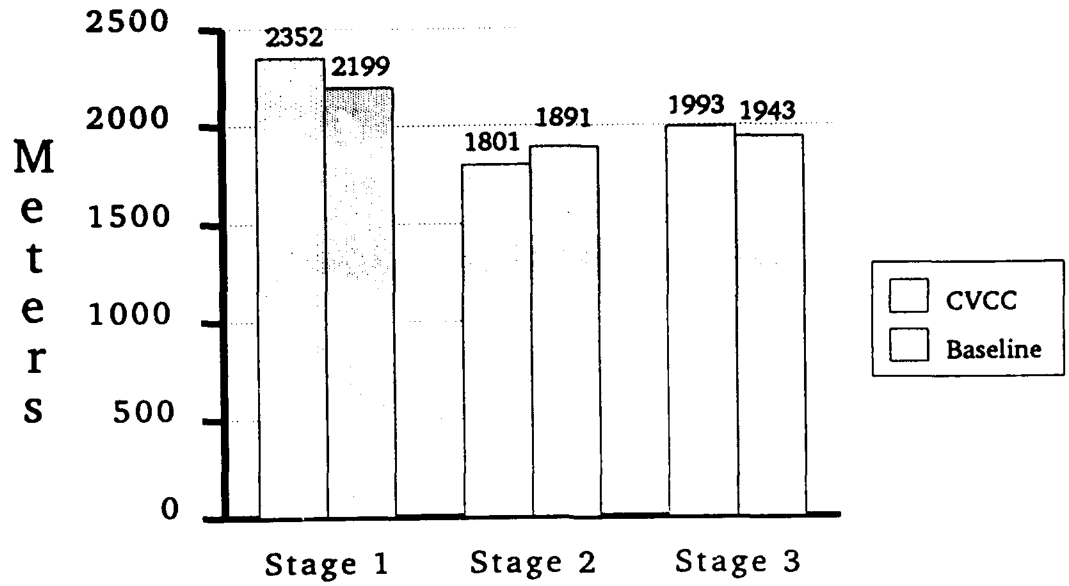

Figure 27. Mean target hit range, in meters.

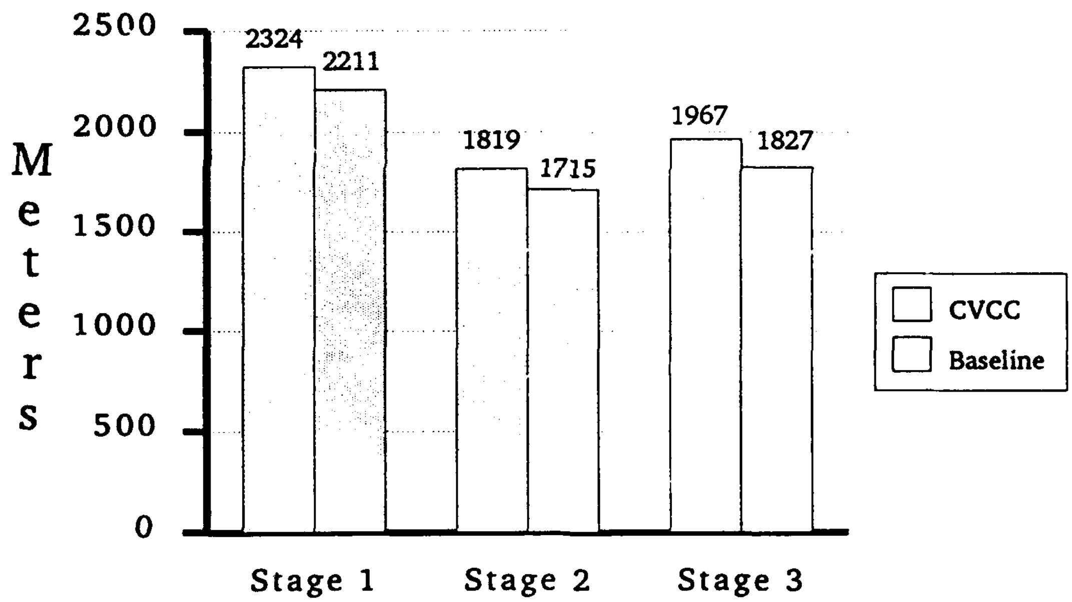

Figure 28. Mean target kill range, in meters.

Hits/round ratio, for manned vehicles. As an index of basic firing accuracy (marksmanship), the proportion of rounds hitting an OPFOR vehicle was computed for each manned tank. Higher ratios indicate better performance. The results (see Figure 29) are expressed as a decimal fraction to indicate the number of hits scored per round fired. Overall, only one in four rounds found their target, despite condition. This finding is a good indicator of the level of gunnery performance that can be expected using the MWTB simulators. The data show no appreciable difference between conditions, although there appears to be a

slight advantage for the Baseline condition (average .26 hits/round in Baseline as opposed to .24 hits/round in CVCC).

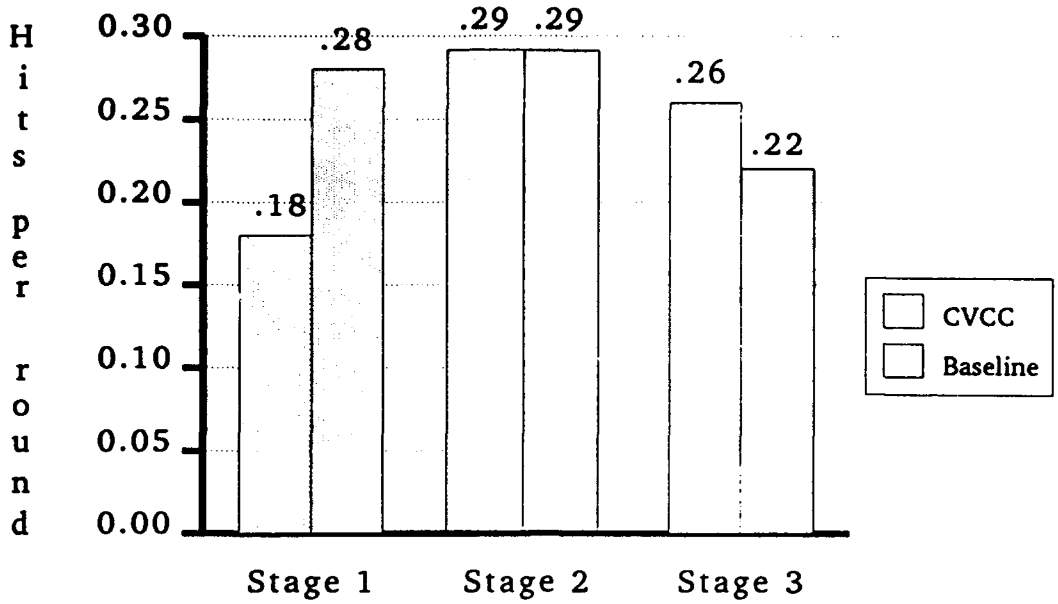

Figure 29. Mean hits per round fired, manned vehicles.

<u>Kills/round ratio, for manned vehicles</u>. Similar to the hits/round ratio, this measure compared the number of enemy vehicles killed to the number of rounds fired by each manned tank. It serves as an indicator of the effectiveness of main gun firings. Higher ratios represent better performance. The data for this measure (see Figure 30) show no appreciable difference between conditions, although the numbers slightly favor CVCC units.

<u>Kills/hit ratio, for manned vehicles</u>. This measure calculated the proportion of hits resulting in target destruction (mobility kills excluded) for each crew. Higher ratios indicate better performance. Figure 31 shows the ratio of kills per hit by condition and Stage. Overall, CVCC crews killed a substantially higher proportion of the targets they hit (average .38), as compared to Baseline crews (average .27).

This result may be attributed to better round selection for the types of targets and ranges involved within the MWTB simulation environment. The data relevant to mean hit and kill ranges suggested greater engagement distances among CVCC units. Generally, higher hit rates are associated with shorter range engagements, a finding that is consistent with the hits/rounds fired data. The factors that go into scoring a kill (given a hit) include the point of impact and angle of attack (i.e., whether the round struck a vulnerable point on the target), and the type of munition (i.e., whether the chemical or kinetic energy was sufficient to cause lethal effects). Given the

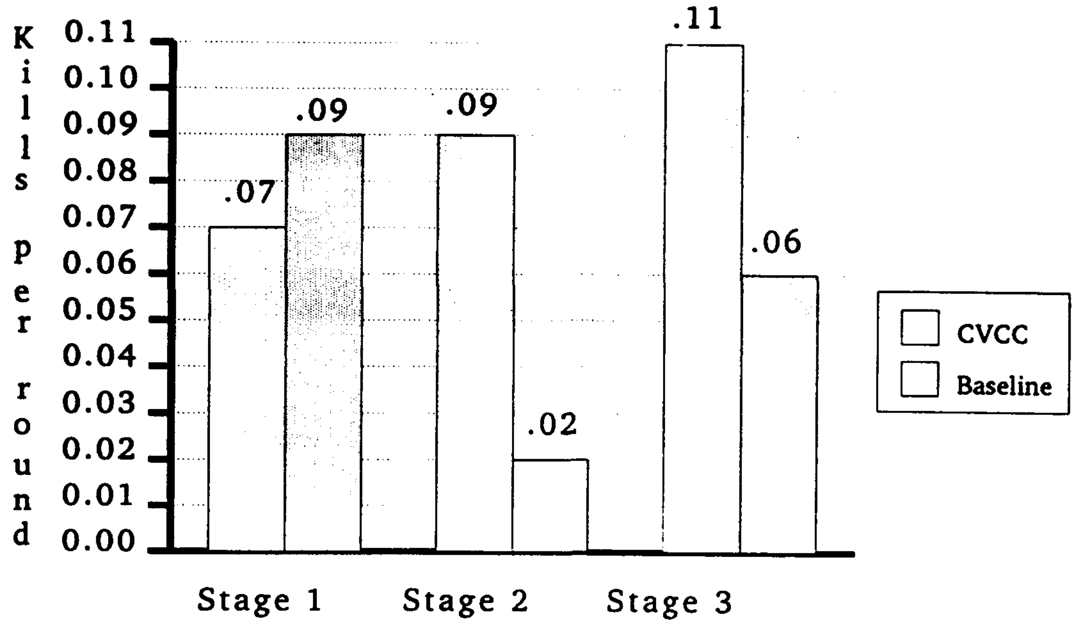

Figure 30. Mean kills per round fired, manned vehicles.

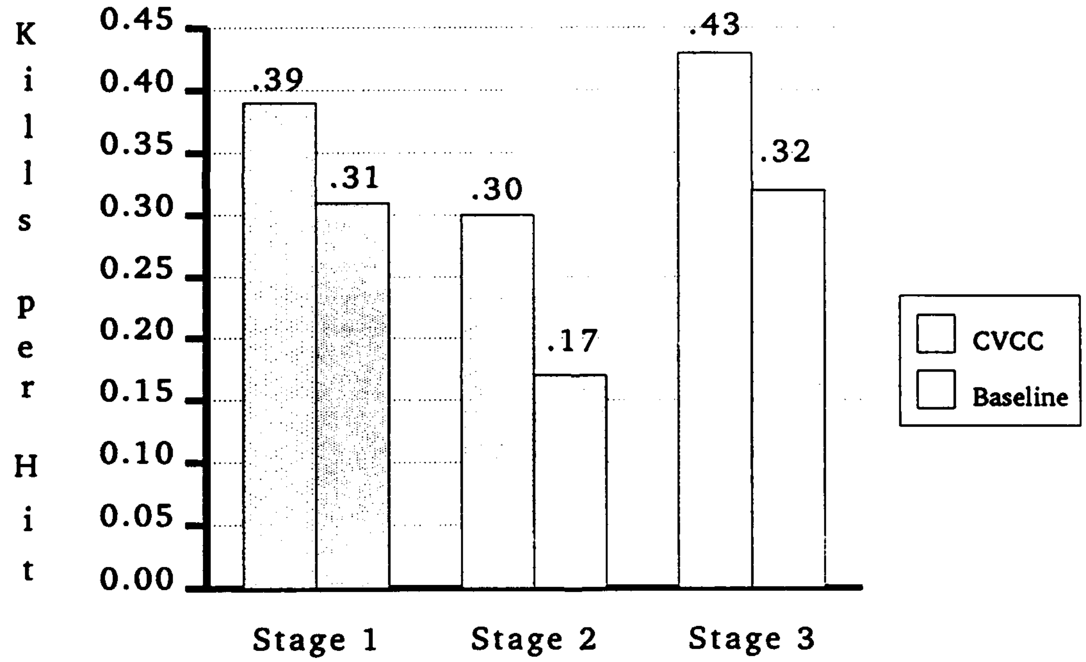

Figure 31. Mean kills per hit scored by manned vehicles.

slightly higher hit rate among Baseline crews, it would appear that munition selection was probably the deciding factor that accounted for higher kill rates among CVCC crews. As will be shown in data relevant to intelligence collection functions, CVCC units more accurately reported OPFOR vehicles, by type. Assuming improved target identification, possibly attributed to better resolution provided by the CITV as compared to the TIS, CVCC crews would have been better informed, and more likely to select the optimal round for the target.

Number of rounds fired by manned vehicles. As a basic index of firing activity by crews in manned simulators, this measure captured the cumulative number of SABOT and HEAT rounds fired by each crew during each stage. Similar to the number of OPFOR vehicles killed by manned vehicles, this index provided a general indicator of the extent to which manned tanks participated in the actual fighting of the battle. It also provided the denominator for the hits and kills per round measures. As shown in Table 21, the mean number of rounds fired did not differ consistently between the CVCC and Baseline conditions.

Number of OPFOR vehicles killed south of designated PL (Stages 1 and 3 only). For each of the two delay stages, lethality in the primary engagement areas was quantified by determining the cumulative number of OPFOR vehicles killed by the battalion south of two successive PLs during the course of the stage. The data were cumulative, by stage. That is, in each stage, the number of kills reported south of the second phase line included those killed south of the first. In general, the earlier the enemy was attrited the better, other factors (such as friendly losses) being equal.

The summary data for these measures appear in Table 22. Baseline battalions consistently killed more of the enemy in the primary engagement areas in both delay stages. This pattern is consistent with the results discussed for the Control Terrain hypothesis in the following subsection, and probably related to the greater stand-off distance which CVCC units tended to maintain (see earlier Move on Surface subsection).

In Stage 1, the cumulative OPFOR losses south of PL Club are comparable between conditions (85 v. 90 vehicles), whereas Baseline units consistently achieved more kills than CVCC units earlier in the stage (i.e., 82 v. 65 vehicles south of PL JACK). However, when compared to the planned scheme of maneuver (see App C, OPORD 200), CVCC units did accomplish an intended task (i.e., destruction of the lead enemy companies--64 vehicles--in the initial engagement areas). However, this trend was not repeated in Stage 3.

Summary. Several of the measures for this function supported the hypothesis that CVCC capabilities would benefit the direct fire engagement of enemy targets. The better prevention of BLUFOR losses and the losses/kill ratio favored CVCC units in Stage 2, and CVCC battalions achieved higher kills per hit ratios in all stages. The lack of significant findings among remaining measures suggests that the engagement performance of command crews using the CVCC system is not decremented as compared to Baseline command vehicle crews. In other words, the CVCC system allows the commander to attend to critical C^2 responsibilities without reducing his tank crew's ability to fight for itself, as compared to Baseline command tank crews.

Table 22

Mean Enemy Kills in Primary Engagement Areas

Measure	CVCC	Baseline
Stage 1		
Number OPFOR vehicles killed south of PL Jack	64.7 (22.7) _n_=6	81.7 (14.3) _n_=6
Number OPFOR vehicles killed south of PL Club	84.8 (11.8) _n_=6	89.8 (9.1) _n_=6
Stage 3		
Number OPFOR vehicles killed south of PL Ace	38.6 (22.1) _n_=5	54.5 (33.3) _n_=4
Number OPFOR vehicles killed south of PL Queen	67.2 (21.8) _n_=5	83.8 (17.2) _n_=4

Note. Measures apply only to delay stages (Stages 1 and 3). Standard deviations appear in parentheses below the means.

Control Terrain

Hypothesis: The CVCC units' ability to control terrain on the battlefield was expected to be significantly better than the Baseline units'. The data indicate comparable performance between Baseline and CVCC units.

Was the battalion bypassed by the OPFOR? Virtually all of the Baseline and CVCC battalions completed Stage 1 without being bypassed by the enemy, and all battalions who completed Stage 3 did so without being bypassed. There was no apparent difference between the two conditions.

Number of OPFOR vehicles penetrating designated line. For each stage, a control line was defined to determine undesirable enemy penetration by the end of the stage. These control lines were based on mission training plans and represented defensive boundaries which the battalion should have controlled to deny enemy penetration during that portion of the delay. In Stage 1, CVCC-equipped battalions allowed an average of 4.17 enemy vehicles (standard deviation, 6.46) to penetrate the control line. In Stage 2, one CVCC battalion permitted two enemy vehicles to penetrate, and another CVCC battalion allowed one

enemy vehicle through. In Stage 3, one CVCC battalion completed the mission with ten enemy vehicles penetrating the control line. This contrasts with performance of the Baseline battalions, none of whom permitted any enemy vehicles to penetrate the designated control line in any of the three stages. It is important to note that although enemy penetrations were more frequent among CVCC units than Baseline units, most CVCC units did successfully prevent enemy penetrations.

For the delay missions (Stages 1 and 3), CVCC battalion performance is best attributed to their tendency to begin the displacement earlier and end their missions with greater stand-off distance than Baseline battalions. These trends were discussed in the subsection addressing the Move on Surface hypothesis. No explanation for the CVCC units' performance in Stage 2 is readily evident, although it can be seen as an isolated event.

Summary. Given no apparent differences in favor of the CVCC condition, the hypothesis that CVCC units will control terrain more effectively than Baseline units is not supported.

Summary of Maneuver BOS Findings.

The CVCC system offers some significant advantages over the Baseline relevant to the Maneuver BOS. Those findings are characterized in Table 23. The better movement performance data are consistent with Du Bois and Smith (1989) and Leibrecht et al. (1992), and demonstrated how CVCC can improve a unit's agility. The engagement data, although not as notable as the findings reported by Quinkert (1990) and Leibrecht et al. (1992), do show that the CVCC system does not inhibit the performance of command vehicle crews. In effect, the CVCC system offers the capability to move forces more rapidly about the battlefield in order to mass fires on known enemy formations. The CITV allows crews to acquire targets more rapidly, and therefore speed the OPFOR's destruction.

Whereas the movement of combat units and the employment of direct fires are important aspects of tactical performance, the ability to integrate other resources is equally critical. The subsection that follows addresses the potential benefit offered by digital communications between the front-line combat force and supporting indirect fire assets.

Fire Support

Issue: Does the CVCC system enhance the Fire Support BOS?

This subsection presents data and findings regarding CVCC's impact on the accuracy of designating enemy targets for engagement with indirect fires. The data presentation follows a narrative describing how the FSO in the TOC coordinated indirect fires in support of both Baseline and CVCC unit operations. The

Table 23

Summary Findings for Maneuver BOS Issue

Function	Findings
Move on Surface	o Greater distance between OPFOR and BLUFOR company CoM at end of engagement among CVCC units. o CVCC units reached counterattack objectives more quickly. o Slightly greater stand-off distance at start of delay among CVCC units. o Better REDCON-1 and LD times in counterattack for CVCC units.
Navigate	o CVCC units completed missions more rapidly. o Greater apparent freedom of movement among CVCC units. o Distance travelled and fuel used performance inconclusive.
Process Direct Fire Targets	o Greater maximum lase ranges among CVCC crews. o CVCC crews acquired targets earlier than Baseline crews. o Baseline crews achieved slightly faster first lase to first fire times. o Slightly higher incidence of fratricide among CVCC units.
Engage Direct Fire Targets	o Higher kills per hit ratio among CVCC crews. o More advantageous loss/kill ratio among CVCC units during the counterattack. o Fewer BLUFOR losses among CVCC units during the counterattack. o Slightly higher proportion of OPFOR killed by CVCC crews. o Baseline units killed more OPFOR vehicles south of first PL in Stage 1, south of both PLs in Stage 3.
Control Terrain	o No demonstrated differences.

data presentation is organized around a single hypothesis, based on the Process Ground Targets function of the Fire Support BOS. The quantitative focus in addressing this issue is the accuracy of CFF reports, reflecting the precision with which battalion elements were able to determine and communicate the locations of enemy targets selected for indirect fire attacks.

Due to the similarity between measures quantifying CFF accuracy and measures supporting the intelligence collection hypothesis in the following subsection, a presentation of intelligence data is integrated with graphics presenting CFF data in this subsection. This approach is consistent with the interacting concerns shared by the FSO and S2 (i.e., targeting and damage assessment data) within a combat unit.

Fire Support Techniques and Procedures

The CVCC system offered several advantages over the Baseline system with respect to fire support operations. Not all of that potential was demonstrated in the battalion evaluation, due to a variety of limiting factors. The fire support data that follow focus entirely on vehicle commanders' performance. Except to the extent that indirect fires affected the battalion's overall performance, the remainder of the indirect fire procedure was not directly evaluated. This narrative is offered to describe the difference in fire support operations between conditions, and to highlight additional potential developments of the CVCC system.

Fire support planning was standardized across all units and conditions. The fire support overlays used by the TOC and participants were as identical as practical. The master copy was an onion-skin paper overlay, that was reproduced mechanically to acetate overlays for participants and TOC staff in both conditions. The digital overlay was developed by transcribing the target locations from the paper map with overlay to the TOC workstation using the overlay tools.

Each group had the option of requesting additional targets during the preparatory phase of the test scenario. The FSO maintained a working fire support overlay throughout the scenario. The first difference between conditions that became readily apparent was the manner in which the additional targets were published. In Baseline, the new targets had to be manually transcribed to participant's existing overlays. In the CVCC condition, the updated overlay was transmitted on the battalion net at the beginning of Stage 1. CVCC participants therefore had, at their disposal, a more accurate and comprehensive fire support overlay.

In all test runs, the FSO executed standardized counter preparatory fires in delay stages, and preparatory fires on the objective during the counterattack. Participants could change the plan, but only by specifically requesting that a given target be included in the schedule. Once again, the ability to update the fire support overlay in CVCC battalions provided an important advantage to units.

During the training scenarios, the TOC cooperated with the participants in developing SOPs regarding the use of indirect fires in the absence of explicit CFFs. For example, if the battalion commander directed that fires be executed on reported enemy formations greater than company size, the FSO would initiate fires based on qualifying SPOT reports if he had not yet received any CFFs. CVCC also made it very easy for the S2 and FSO to exchange information. As CFFs were received, the FSO managed them according to the priorities of fire and target engagement priorities established in the OPORD, as modified by the commander during the course of the scenario. The FSO also

cleared fires based on the last known location of friendly elements.

In Baseline, the FSO maintained current locations of fire support elements as reported to him by the fire support element terminal, which served as his interface to the simulation system. The FSE terminal represented the normal voice and TACFIRE digital interface between a maneuver battalion FSO and his supporting FA headquarters, as well as communications with the maneuver battalion's mortar platoon. The FSO used those data to post mortar and howitzer unit locations on his map. He could estimate each units' coverage using an acetate-based template. The FSO posted friendly maneuver unit positions based on information from the S3 Air, in order to clear fires. All CFFs were received from participants via voice radio, and transcribed manually. Fire missions were executed using the FSE terminal. Unless he received assistance from other staff members, the FSO was limited in the number of CFFs he could manage. The FSO also allocated the fire mission to a specific asset (mortar platoon or section, howitzer battery or platoon) when he entered the CFF to the FSE terminal, thus performing a portion of the duties normally associated with the supporting fire direction center (FDC).

In CVCC, the FSO maintained current fire support unit locations using the FSE terminal, as in Baseline. He posted those to his TOC workstation map display using overlay tools, and could also integrate a range fan for each fire support unit. Thus, when a fire mission was posted to the map, the FSO could easily determine which fire support units could answer that request. Friendly maneuver unit locations were automatically posted to the FSO's TOC workstation, allowing him to clear fires more effectively than in Baseline. Fire missions were received digitally, augmented by voice transmissions for coordination and special requirements, such as FPFs. The digital system made it possible to receive multiple CFFs while processing earlier requests. The volume of CFFs that could be received was much greater in CVCC. While that capability increased the FSO's sorting requirement, the TOC workstation's In-Folder display provided a menu from which the operator could easily select CFFs based on the priority of fires. Fire missions were executed using the FSE terminal, as in the Baseline condition.

One drawback that was noted during the current evaluation was that the system posted locations (i.e., position icons) for dead and immobilized BLUFOR vehicles. Thus, although the unit had withdrawn from an initial position, the picture on the TOC workstation suggested that friendly elements were still forward. The unit status display in the operational effectiveness module could indicate current friendly losses, to help deconflict the situation depicted on the map screen. Also, verbal confirmation from the company commander or XO helped resolve the situation. Until the status of those stay-behind vehicles was confirmed, however, the FSO was reluctant to clear fires proximate to those vehicles.

Another drawback noted during the current evaluation was a lack of automated feedback. The CVCC system provided no digital response to the originator to signal that a mission was in progress, or to clarify which mission was being fired. The FSO could provide verbal feedback, but that process was relatively involved. Furthermore, it could become confusing if one participant generated multiple CFFs in a short period of time. A direct, automated link between the originator and the FDC could facilitate a digital feedback mechanism, but as explained earlier, such a data transfer capability was not modelled in the battalion evaluation.

Process Ground Targets

Hypothesis: The CVCC units' ability to process ground targets for indirect fire on the battlefield was expected to be significantly better than the Baseline units'.

The two measures that supported this hypothesis (CFF accuracy, and percent of CFFs with correct type) were very similar to those used to support the analysis of intelligence performance, in the next subsection. The composite data for fire support and intelligence functions are illustrated in Figures 32 and 33. The number of CFFs recorded in Stage 3, particularly among Baseline units, was insufficient to support a meaningful analysis of Stage 3 data, partially due to the number of Baseline units that did not execute the final stage. Therefore, data are presented for Stages 1 and 2, only.

Throughout the evaluation, CVCC units' CFFs were far more accurate than those sent by Baseline units. As a result of more accurate CFFs, the FSO was able to target OPFOR formations more effectively. Also, by capitalizing on the automated position display capability on his TOC workstation, the FSO could clear fires more effectively in both offensive and defensive operations. Furthermore, in the absence of explicit CFFs, the FSO could fire on targets identified by CONTACT[14] and SPOT reports, which were also more accurate among CVCC units as will be shown in the presentation of intelligence collection data. Table 24 provides summary data (means and standard deviations) on CFF measures, by stage and condition. Figures 32 and 33 graphically demonstrate the difference in both linear accuracy and target identification performance between conditions.

The reader is reminded that qualified, fire support team (FIST) chiefs were not part of the company manning structure in this evaluation. Company XOs assumed that responsibility. Baseline participants were provided the format for CFFs, whereas CVCC participants could bring up the CFF format in their CCDs. XOs received no dedicated refresher training on indirect fire

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[14]The CONTACT report format used for the battalion evaluation included a grid location for the contact.

Table 24

Fire Support Performance Data by Stage and Condition

Measure	Stage 1 CVCC	Stage 1 Baseline	Stage 2 CVCC	Stage 2 Baseline
CFF location accuracy, in meters	526.75 (475.64) n=25	4087.15 (8022.25) n=9	679.17 (896.97) n=15	2981.29 (1621.19) n=7
Percent of CFFs with correct type	90.57 (17.70) n=25	73.33 (25.50) n=9	87.50 (28.87) n=16	66.67 (23.57) n=7

Note. Standard deviations appear in parentheses below the means.

procedures to reinforce the skills they brought into the evaluation. Therefore, any potential disadvantage attributable to the absence of a trained FIST chief was held constant across all test groups.

Mean accuracy of CFF locations. CFF accuracy was quantified by comparing the enemy location specified in each CFF to the actual location of the nearest enemy unit at the time the CFF was transmitted. Only CFFs with valid grid locations were analyzed. In practice, the CoM of the three enemy vehicles (regardless of type) nearest the reported location defined the location of the nearest enemy unit. Only those unit and vehicle commanders transmitting scorable CFFs contributed values for this measure. An average was determined for each vehicle that transmitted one or more scorable CFFs during a stage, such that the number of observations (n) represents the number of vehicle commanders that contributed useable data in that stage, rather than the number of CFFs scored. This computational process yielded distance measurements of the discrepancies between actual and reported locations. The smaller the discrepancy, the better the accuracy. Linear targets (i.e., final protective fires or FPFs) were not scored.

Procedurally, with the exception of FPFs[15] and fires targeted on suspected enemy positions (i.e., preparatory fires), participants were directed to report actual current enemy positions in their CFFs. The FSO adjusted the aim point according to the reported or expected direction of enemy movement (if applicable), based on the elapsed time from the original CFF.

[15]Throughout the evaluation, linear targets were planned immediately in front of BPs to cover the withdrawal of BLUFOR elements. Although their practical use differed from a true FPF, they were referred to as FPFs for the sake of convenience.

Thus, in all cases, CFFs on targets of opportunity could be taken at face value for data analysis purposes.

As seen in Figure 32, the CFFs submitted by CVCC participants were substantially more accurate than those submitted by Baseline participants. Table 24 shows that accuracy differed significantly between stages as well. The standard deviations for these data are smaller for the CVCC-equipped battalions than for the Baseline battalions. This indicates more consistent performance when using CVCC equipment, a distinct benefit on a fast-paced, highly fluid battlefield.

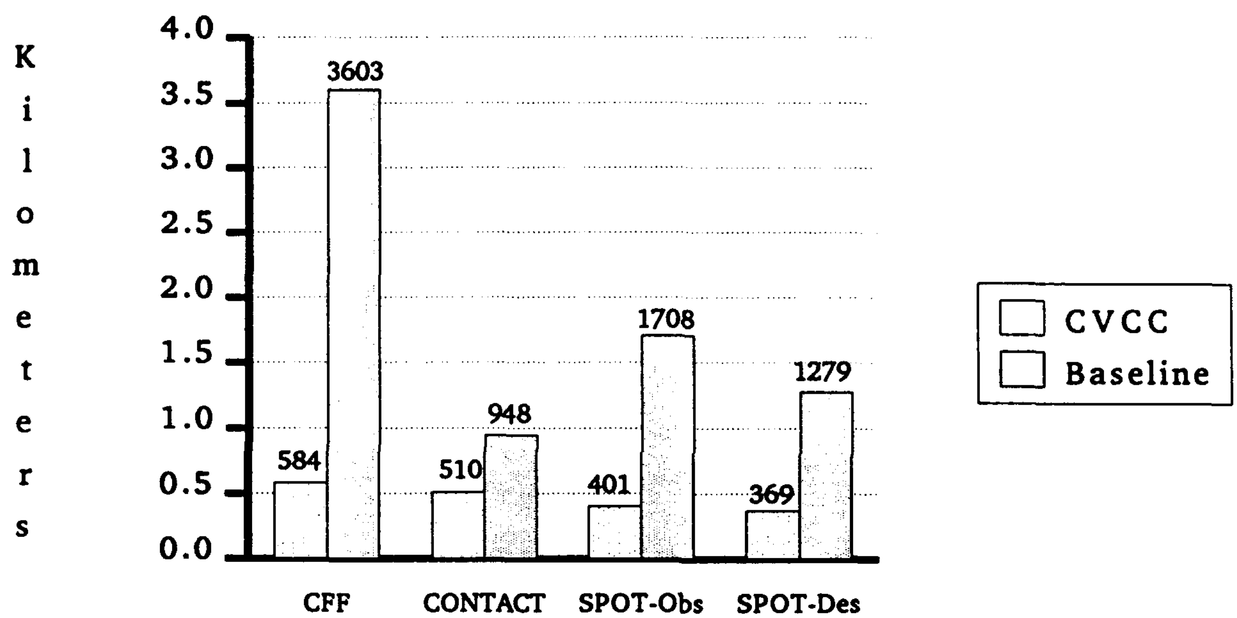

Figure 32. Mean reported location accuracy for CFFs, CONTACT reports, and SPOT reports.

Of the CFF requests transmitted by Baseline participants, many were not scorable because they lacked adequate location information. Out of all CFFs generated by Baseline units, 66 percent were missing target locations. A virtually identical proportion of voice CFFs from CVCC participants (65%) were also unscorable, but CVCC units used voice CFF formats less than 3 times per scenario, on average.

These data show that the CVCC capabilities increased both accuracy and consistency of performance in reporting enemy locations in CFF reports.

Percent of CFFs with correct type. This measure quantified the accuracy of unit and vehicle commanders' enemy vehicle identification in their requests for fire support. Scoring was accomplished by comparing the reported vehicle type with the actual types of enemy vehicles visible to the reporting vehicle

at the time the CFF was transmitted. Only reports containing a valid grid location and valid type of enemy vehicle (e.g., tank or personnel carrier) were scored. If one or more enemy vehicles of the type reported were visible, the CFF was scored "correct." For each commander sending scorable CFFs, the proportion scored "correct" was calculated.

Figure 33 displays the data for this measure, showing a consistently greater proportion of CFFs containing correct enemy vehicle types in the CVCC condition. The performance advantage of CVCC-equipped units was significant across all stages.

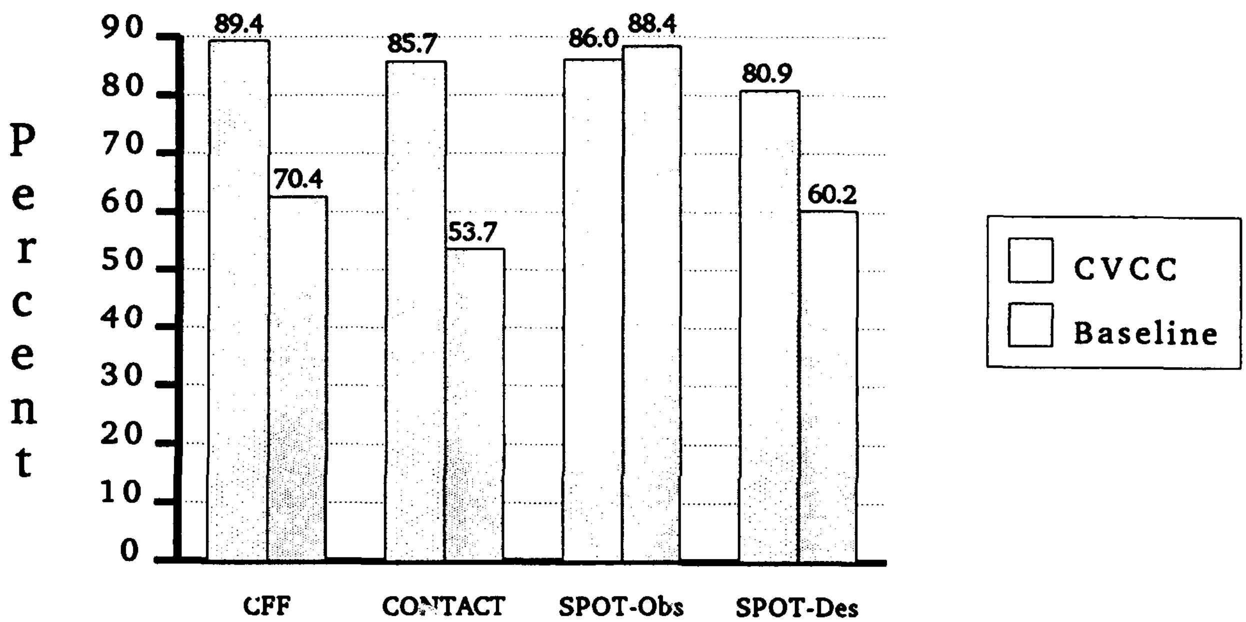

Figure 33. Mean descriptional accuracy of CFFs, CONTACT reports, and SPOT reports.

Paralleling the preceding measure, the standard deviations for this measure are smaller for the CVCC condition in both stages. The consistency of this trend suggests less variability of performance when using the CVCC equipment. This is also an important indicator to the reliability of performance among CVCC-equipped crews.

These data establish that the CVCC capabilities increase the overall accuracy and consistency of reporting the type of enemy vehicle in CFF reports.

In both of the measures for CFF performance, more CVCC participants were able to send useful indirect fire requests, as evidenced by the numbers of observations indicated in Table 24. The numbers do not necessarily reflect the number of CFFs generated, but they do indicate that, given the CCD, approximately three times as many participants were able to

generate useful CFFs in Stage 1, and approximately twice as many did so in Stage 2. An occassional comment in debriefings attested to the ease with which an unpracticed observer could format and send an accurate CFF, using the CCD (Meade et al., in preparation). Although it was not possible to verify whether this resulted in a greater number of actual calls for indirect fire, a greater volume of requests is a reasonable expectation.

This finding is both an advantage and a disadvantage. Given the accuracy of digital CFFs as described in the preceding measures, a higher volume of CFFs would provide the FSO a more up-to-date list of valid targets for available artillery tubes. Furthermore, the ease with which the FSO can collect targeting data from other reports (e.g., SPOT reports) further enhances his ability to maintain a valid target list. In the test scenario, the only operational constraints on the availability of fires were (a) indirect fire asset movement times and (b) the FSO's ability to manually enter CFFs in the FSE terminal. Other real-world constraints on fire support availability (e.g., competing priorities, ammunition supply rates, firing unit target signature, equipment and personnel status) were not replicated. An important implication of these factors is that an increased volume of CFFs would have a corresponding impact on the need to manage indirect fires (e.g., enforce priorities and delivery rates) at all levels. By contrast, the improved accuracy of targeting data would enable the firing unit to deliver effective fires with fewer resources.

Summary of Fire Support BOS Findings

Table 25 summarizes findings pertaining to the processing of ground targets under the Fire Support BOS. The data clearly document that the CVCC capabilities enhance both location and identification accuracy in the process of requesting fire missions from mortar and artillery elements. In turn, this can be expected to improve the accuracy of indirect fires delivered on enemy targets, contributing to more effective massing of friendly fires.

The superior location accuracy afforded by the CVCC system is undoubtedly due largely to the ability to input precise locations to CFFs by lasing. The CVCC's advantage in terms of target identification accuracy most likely results from the CITV's surveillance capabilities as well as the digital exchange of information about enemy elements, including the display of report-based icons on the tactical map. The CFF formats in CVCC also apparently prompted more complete information to the TOC, as evidenced by the greater volume of scorable information. Both of these factors are consistent with the likely improvement in situational awareness on the part of CVCC unit and vehicle commanders. In summary, the CVCC capabilities are especially valuable in ensuring that complete and accurate locations were submitted with CFF reports.

Table 25

Summary of Findings Related to Fire Support

Measures	CVCC Advantages
Accuracy of CFF Locations	CFF report location accuracy greater for Stages 1 and 2.
% CFFs with Correct Type	CFF report vehicle identification accuracy greater for Stages 1 and 2.
# CFFs with complete information	Greater volume of usable information in Stages 1 and 2.

The results presented in this section indicate how CVCC capabilities can help unit and vehicle commanders increase the effectiveness of indirect fires. The following section on the Intelligence BOS discusses the CVCC's impact on the accuracy of information reported about enemy activities.

Intelligence

Issue: Does the CVCC system enhance the Intelligence BOS?

This subsection examines the effect of CVCC capabilities on collecting intelligence information. One hypothesis, based on the Collect Threat Information component of the Intelligence BOS, organizes data presentation. The data presentation is preceded by a description of intelligence analysis procedures employed in the Baseline and CVCC conditions, and observations on potential uses of the CVCC system to enhance tactical intelligence operations.

Intelligence Techniques and Procedures

In both the Baseline and CVCC conditions, the battalion S2 provided standard information to participants during the preparation stage. Intelligence overlays, to include a decision support template with named and targeted areas of interest (NAI/TAIs) were prepared in both acetate and digital formats, using the same procedures as for the fire support overlays.

Once the simulation was under way, the S2 received the tactical reports and external intelligence provided by the brigade S2, and attempted to compile an analysis of the developing enemy situation. Reports were received and posted to the intelligence situation map. In Baseline, the S2 used a paper map with an acetate drop. In CVCC, the map display on the TOC

workstation replaced the paper map. The S2 manually tallied enemy vehicles observed and destroyed in both conditions, in order to analyze the enemy's deployment.

The automated message handling capabilities in CVCC enabled the S2 to receive and process a larger volume of tactical information. Report aggregation routines built into the software facilitated the analysis by grouping like reports that showed similar types and numbers of enemy vehicles in close proximity to each other in both time and space. As the enemy situation developed, the S2 was able to develop a working overlay of reported enemy activities throughout the battalion's battle space. That updated overlay could be transmitted on demand, to provide the commander a graphic representation of the current enemy situation. Although not implemented during the battalion evaluation, the overlay could have included anticipated approach routes and times for follow-on echelons, based on known locations and assumed march rates.

By contrast, in Baseline the S2 was harder pressed to receive, analyze, and post enemy information. On request, he could describe the situation as he saw it via voice radio. However, as shown in relevant portions of the command and control analysis earlier in this section, the quality of information sharing associated with voice-only media did not compare favorably with CVCC's digital capability.

An aspect of the CVCC system that was not implemented during the scenario was the employment of CVCC-equipped elements in reconnaissance missions. CVCC capabilities could have facilitated the rapid development and dissemination of a reconnaissance and surveillance plan, and allowed the S2 to monitor and adjust reconnaissance operations during execution. Digital reporting from the recon elements also would facilitate the post-hoc analysis and dissemination of the results.

Overall, the CVCC system provides the S2 a variety of useful tools to collect and analyze intelligence data.

<u>Collect Threat Information</u>

Hypothesis: The CVCC units' ability to collect threat information on the battlefield was expected to be significantly better than the Baseline units'.

During the battalion evaluation, on-line intelligence gathering within the test unit was limited to tactical reporting from maneuver units. The battalion scouts were included in the simulation, but they were given security missions (i.e., flank screen) in areas not threatened by the OPFOR during the scenario. Ground surveillance radar (GSR) units were notionally deployed in the sector, under brigade control, but no scripted tactical intelligence was attributed to those units. The measures supporting this analysis quantified the accuracy of reported

locations for SPOT, SHELL, and CONTACT reports, and the descriptive accuracy of SPOT and CONTACT reports. Figures 32 and 33 (presented in the previous subsection) illustrate the overall performance trends for these measures. Table 26 shows performance data by stage and condition.

Table 26

Mean Performance Data for Threat Information Collection Measures, by Stage and Condition

Measures	Stage 1 CVCC	Stage 1 Baseline	Stage 2 CVCC	Stage 2 Baseline	Stage 3 CVCC	Stage 3 Baseline
Report accuracy average deviation, in meters						
CONTACT reports	538.27 (681.31) n=30	881.13 (1022.42) n=16	600.37 (840.10) n=23	988.88 (1471.44) n=10	355.67 (497.26) n=19	1043.29 (1762.46) n=7
SPOT reports (observed)	436.70 (470.39) n=34	1993.28 (2774.19) n=23	369.39 (433.76) n=25	1331.22 (1490.23) n=13	375.7 (588.2) n=18	884.5 (-.-) n=2
SPOT reports (destroyed)	394.44 (423.19) n=32	1430.09 (2381.98) n=22	362.96 (396.43) n=25	1040.97 (1392.92) n=11	328.6 (532.1) n=17	884.5 (-.-) n=2
SHELL reports	2034.27 (1033.36) n=22	1648.10 (595.52) n=15	1662.83 (577.95) n=15	1333.20 (429.22) n=5	1888.25 (645.23) n=25	1783.67 (751.28) n=7
Percent of CONTACT reports with correct type	84.72 (29.20) n=30	59.38 (31.01) n=16	88.70 (26.25) n=18	50.71 (32.14) n=14	84.47 (30.32) n=19	46.43 (30.37) n=7
Correctness of SPOT reports (percentage)						
Observed	81.86 (27.29) n=34	83.82 (25.12) n=23	95.16 (11.88) n=25	94.29 (17.90) n=14	81.47 (30.45) n=19	100.0 (-.-) n=2
Destroyed	78.99 (27.44) n=33	54.55 (40.31) n=23	88.58 (17.13) n=25	68.94 (32.53) n=12	73.52 (32.08) n=18	73.08 (-.-) n=2

Note. Standard deviations appear in parentheses below the means.

Throughout the evaluation, CVCC units sent significantly more accurate CONTACT and SPOT reports. Reported grids in both types of reports were significantly more accurate among CVCC units than among Baseline battalions. CVCC battalions also sent a significantly higher proportion of reports with correct OPFOR vehicle types and numbers. By contrast, SHELL reports sent by Baseline units tended to be more accurate than those reported by CVCC battalions, although the difference was not substantial.

Accuracy of CONTACT report locations. CONTACT report location accuracy determined how close the reported enemy location was to actual enemy locations. The measure was computed as the distance, in meters, from the reported location to the nearest OPFOR vehicle at the time the report was sent. Only reports containing valid locations were scored. As with the CFF measure in the preceding subsection, the number of observations (n) is the number of vehicle crews that contributed one or more scorable reports during the stage. The average distance for all reports in the stage was computed for each crew, and the results were then compiled to determine the means and standard deviations shown in the table.

Throughout the battalion evaluation, the CONTACT report format specified in the unit SOP required the type of contact (e.g., tanks, PCs) and grid locations. This contrasted with the more common format used by units in the field and contained in the Armor School SOP (Department of the Army, 1990b), which requires only the type of contact and cardinal direction (e.g., "CONTACT, TANKS, SOUTH, OUT").

The mean deviations for this measure can be found in Table 26 and are illustrated in Figure 32. Location accuracy was significantly better among CVCC units than among Baseline units. The largest difference between conditions occurred in Stage 2, with Baseline units' deviations averaging approximately three times those of CVCC units. The differences between units were consistent throughout Stages 1 and 2. In all three stages, the standard deviations for CVCC battalions were substantially smaller than those for Baseline battalions, indicating more consistent and reliable reports. As discussed earlier in this report, the more consistent performance of the CVCC units is a distinct advantage.

Although excluded in the analysis, one data point that clearly demonstrates the benefit of LRF input to reports was a Baseline CONTACT report (Stage 1) that was 41,778 meters off. This most likely occurred due to the transposition of grid numbers (e.g., reporting a grid of 456123 as opposed to 123456). While such a mistake would eventually be discovered and corrected as message information was processed, such an event typically involves follow-up transmissions between the originator and other stations on the network to confirm the actual location of the enemy activity. Given the automated reporting features inherent to the CVCC system, analogous events are very unlikely.

In virtually all Baseline units, leaders continued to use the more familiar CONTACT report format throughout training and into the test scenario. Generally, the participants acknowledged the advantage of providing grid locations, but they were also concerned that the time necessary to determine and transmit the grid was critical. A very common procedure was to alert the battalion to the contact without the grid, then follow up with the grid location in a second CONTACT report or a SPOT report.

Twenty-nine percent of all Baseline CONTACT reports (38.3 out of 133.7 per stage, on the average) could not be scored for accuracy due to lack of valid locations.

In most CVCC units, leaders quickly concluded that the time necessary to format and transmit the digital CONTACT report was also a critical factor. Hence, almost all CVCC units also chose to use the more familiar, type/direction CONTACT report format as an immediate, audio alert, that was to be followed by detailed information as soon as possible. Forty percent of the voice CONTACT reports among CVCC units (80 out of 198) were not scorable for that reason.

Considering that CONTACT reports serve primarily an alerting function, this does not represent a critical loss of tactical information. However, valuable intelligence information is lost when the enemy location is not specified. Inspection of the cell sample sizes for CONTACT report accuracy (Table 31) revealed that more CVCC commanders sent CONTACT reports containing valid grid locations. Also, although the proportion of non-scorable, voice CONTACT reports was roughly equal between conditions (38% vs. 40%), the raw number of unscorable reports in Baseline is roughly twice the number in CVCC. Thus, the CVCC capabilities enabled participants to provide a larger quantity of fully usable enemy information to the TOC staff.

Accuracy of SPOT report locations. The same procedures used to compute accuracy of locations specified in CONTACT reports were used for locations in SPOT reports. Both Baseline and CVCC units were instructed to report OPFOR vehicles observed and destroyed. The accuracy of reported locations was computed for each type of information, yielding two submeasures (i.e.: "SPOT-Obs" for observed, and "SPOT-Des" for destroyed in Figures 32 and 33).

As with CFF and CONTACT reports, SPOT reports were substantially more accurate in the CVCC units than in Baseline units. Likewise, reports from CVCC units were more consistent, as evidenced by smaller standard deviations in each category. This finding was true for both stages (i.e., 1 and 2), and for both observed and destroyed OPFOR vehicles. This finding can most likely be attributed to the accuracy resulting from the use of the LRF to input report data.

An average of 52.7 unique SPOT reports per scenario were sent by Baseline unit and vehicle commanders. An average of 13.8 reports (26.3 percent) did not contain valid locations and were therefore excluded from the analysis for accuracy. This indicates a substantial proportion of flawed SPOT reports within the Baseline condition.

Accuracy of SHELL report locations. SHELL report location accuracy was quantified as the deviation, in meters, between the reported and actual locations of OPFOR indirect fire attacks.

The means among Baseline units tend to be smaller than among CVCC units, with the most notable difference occurring in Stage 1 (1648 meters in Baseline, 2034 meters in CVCC). Given the variability of the data, the differences between conditions cannot be considered reliable. Furthermore, given the area fire nature of artillery, the difference is not meaningful from an operational standpoint.

A possible explanation for the inaccuracy of the CVCC condition in this case may be attributed to the use of the LRF to input report locations. In most other cases the LRF will likely obtain a reliable return from a solid target, and therefore provide relatively accurate input to the CCD for tactical reports. In the case of artillery, however, participants may either have input the attack location by hand using the CCD touchscreen, or lased to a point on the ground near the artillery bursts. Either of these options would have returned relatively inaccurate locations.

An average of 23.4 SHELL reports per scenario were transmitted by Baseline unit and vehicle commanders. Of these, an average of 6.75 per scenario (28.8 percent) were not scorable due to missing locations.

The data for these three measures (i.e., CONTACT, SPOT, and SHELL report location accuracy) show that, in those cases where the system could capitalize on reliable range returns from the LRF, accuracy was remarkably better among CVCC units than among Baseline units. This finding is consistent with the CFF report accuracy data from the Fire Support BOS (discussed earlier in this section), where similar procedures were used to quantify location accuracy.

Percent CONTACT reports with correct type. This measure was concerned with the descriptive accuracy of CONTACT reports. For each vehicle, an automated data reduction routine determined the proportion of CONTACT reports sent from that vehicle during the stage that contained correct OPFOR vehicle identifications. A vehicle identification was considered correct if any of the reported type vehicle shared intervisibility with the reporting vehicle when the report was transmitted.

Throughout all three Stages among all CVCC groups, CONTACT reports averaged better than 84% correct, while Baseline units' CONTACT reports averaged less than 60% correct (see Figure 33). This difference yielded a statistically significant between-conditions advantage in favor of CVCC units.

Correctness of SPOT report number and type. This measure was concerned with the number and type of vehicles observed and destroyed. Given a SPOT report containing some number of a certain type vehicle (e.g., 3 tanks observed), an automated data reduction procedure determined the number of like OPFOR vehicles with current intervisibility to the sender, regardless of actual

grid location. The result provided the numerator for the scoring procedure, and the reported number became the denominator. Values greater than 100% were reduced to 100%. In effect, the data reduction procedure penalized over reporting, but excused under reporting. All reports sent from a given vehicle in a stage were averaged to provide a single data point for that vehicle and that stage. The data reported in Table 26 are averaged for all vehicles, by stage and condition.

While both over-reporting and under-reporting are operationally meaningful errors, the decision to penalize one and not the other was made due to simulation fidelity factors. Given intervisibility with a number of OPFOR vehicles, a participant is more likely to not see some of the vehicles than he is to see more than are actually present. Therefore, by not penalizing for under-reporting, the data reduction procedure gave the benefit of the doubt to participants, commensurate with known simulation limitations.

Figure 33 presents the data for this measure graphically, collapsed across stages for observed and destroyed vehicles. Table 26 provides more detailed data. Overall, the data show a considerable advantage in favor of the CVCC condition.

Among the data for OPFOR vehicles observed, performance between conditions is essentially comparable. When the data are collapsed across both stages, CVCC units reported correctly 87.5 percent of the time, as opposed to 87.8 percent in Baseline units.

By contrast, the data for OPFOR vehicles destroyed is substantially more accurate among CVCC units. Overall, CVCC units were 83.1 percent correct as opposed to 59.5 percent correct for Baseline units.

Given the treatment of the data, these results indicated that units in both conditions over-reported the number of OPFOR vehicles observed about 12 percent of the time. With respect to OPFOR vehicles destroyed, however, over-reporting was clearly more common among Baseline units. The potential impact of this effect is meaningful. When the S2 tallies SPOT report data, his estimate of the OPFOR order of battle is not affected by condition, but his estimate of OPFOR vehicles destroyed is more likely to be overstated in the Baseline condition. Therefore, he is more likely to underestimate current OPFOR combat power.

Summary of Intelligence BOS Findings

Table 27 summarizes findings relevant to the Intelligence BOS. CVCC units rendered SPOT and CONTACT reports that were significantly more accurate than Baseline units' reports, in terms of location accuracy. With respect to SHELL report location accuracy, no meaningful differences were found between conditions. CVCC units also rendered CONTACT reports with

consistently more accurate OPFOR vehicle identifications than Baseline units, and CVCC units reported the number and type of OPFOR vehicles destroyed more accurately in SPOT reports. The accuracy of SPOT reports quantifying the number and type of OPFOR vehicles observed was comparable across conditions. Given generally better intelligence gathering among CVCC units overall, however, it can be concluded that the CVCC system improves unit performance within the Intelligence BOS.

Table 27

Summary of Findings Related to Intelligence

Measure	Findings
Location accuracy in reports	Greater among CVCC units for CONTACT and SPOT reports. Comparable between conditions for SHELL reports.
Vehicle identification in reports	Higher percentage of reports with correct identifications from CVCC units.
Number of OPFOR vehicles reported	Higher percentage of OPFOR vehicles reported, by type, among CVCC units.
Volume of usable data in reports	Greater among CVCC units.

The implication of enhanced intelligence reporting is a marked improvement in the data available to the unit commander and staff regarding the enemy situation. As stated in the summary of Command and Control BOS findings, the CVCC system gives the commander a better view of the overall tactical situation, and therefore enhances his ability to dictate the terms of battle to the opposition.

Battlefield Integration

This subsection addresses implications that transcend individual battlefield operating systems. These findings are organized around the tenets of Army operations and the dynamics of combat power outlined in FM 100-5 (Department of the Army, 1993a). This discussion is based on Battle Master observations during the conduct of tests, participant feedback during debriefings (Meade et al., in preparation), and a synthesis of findings presented in earlier subsections of this report.

Tenets of Army Operations

Initiative. The CVCC system cannot instill initiative, but it does have the potential to facilitate operations within offensively-minded units. This potential results from the improved agility within CVCC units, the enhanced view of the friendly situation provided through the CCD, and the greater ability to disseminate battlefield intelligence. CVCC provides the commander and staff with a tool that allows them to get inside the enemy's decision cycle early. This capability opens opportunities to seize the initiative from the enemy.

Agility. The findings from the "move on surface" and "navigate" functions suggest that CVCC units can move more quickly than their Baseline counterparts. For example, CVCC units moved further, in less time than Baseline units in Stage 1 of the test scenario. Also, CVCC units reacted faster to changes in mission, as evidenced by better REDCON-1 and LD times in Stage 2. The test scenarios offered participants few opportunities to shift forces to meet unanticipated contingencies, or to take advantage of an enemy vulnerability. However, situations were observed during selected iterations in which commanders recognized such a need. The common challenge in all those cases was the need to communicate the shift to subordinates.

In Baseline units, the commander could verbally direct the subordinate unit to a desired location, using an existing graphic or grid location. Feedback from the subordinate unit consisted of an acknowledgement and periodic progress reports, all subject to transposition and navigational error. In CVCC, the TOC could translate the commander's directive into a new graphic, and transmit that on the net for everyone's benefit. As an alternative, the battalion commander could personally generate a route for the subordinate, and transmit that graphic directly to the company commander. As the subordinate moved in CVCC, the battalion commander had constant, real-time data on the unit's progress. Furthermore, as enemy contacts developed, CVCC units could use the digital reports to reorient and reposition more efficiently than their baseline counterparts.

Even more important than the tangible effects described in the preceding paragraphs, the CVCC system can significantly improve leaders' "mental agility." As described under initiative, the tactical display can help the commander recognize opportunities to strike against the enemy.

Depth. To the degree that CVCC enhanced the ability to see the battlefield (i.e., friendly positions, friendly operational status, and intelligence data presented in real time and overlaid on the tactical map), it also enhanced the unit's ability to manage its resources over time. The operational effectiveness module enables the unit to easily identify critical resource concerns. The improved agility described earlier enables the commander to more easily disengage a portion of his force for

rearming and resupply, and shortens that element's turn-around time. Assuming the extension of selected CVCC capabilities (i.e., position reporting) to organic CSS elements, the staff can push support forward more effectively, particularly in the offense, to extend the battalion's overall capability. These advantages extend the battalion's operational depth in both time and space.

Synchronization. CVCC units, by virtue of the tactical display provided in the CCD, enjoyed an enhanced capability to synchronize movement and fires. By being able to monitor the progress of subordinate and adjacent units, commanders relied less on voice radio communications to coordinate maneuver. Likewise, the fire support officer could visually monitor the units' progress and control fires more effectively.

The enhanced capability to synchronize combat operations was demonstrated primarily in the conduct of the counterattack. CVCC units came closer to meeting LD times than Baseline units, and massed fires on the OPFOR more often than Baseline units.

Versatility. As with the tenet of initiative, versatility is much more a state of mind than the result of technological advantage. Yet, given a commander and staff with the ability to anticipate and react quickly to developing tactical and strategic factors, the enhanced communications capability provided in the CVCC system enables the unit to respond to such changes more efficiently. In effect, CVCC increases the options avalable to the commander in many situations.

Dynamics of Combat Power

The dynamics of combat power involve maneuver, firepower, protection and leadership. The first two dynamics correspond with BOS that have been addressed in preceding discussions, and will not be recounted here, except as they interact with the dynamics of protection and leadership.

Protection. During Stage 1 of the delay, CVCC units maintained greater stand-off from the OPFOR while still inflicting damage, and retained a larger percentage of their own combat power than did Baseline units. Furthermore, CVCC units achieved a more advantageous loss-kill ratio. The same holds true in the counterattack (Stage 2), but not in the subsequent delay (Stage 3).

Fratricide prevention is also an important aspect of force protection. The results of the current evaluation suggest that the CVCC system does not offer any substantial advantage over the Baseline system. CVCC units had greater than twice the number of fratricide events as Baseline units, despite the IFF capability built in to the CITV. This result is clearly a matter that must be carried forward for further development. As suggested earlier in this report, the problem may have been that the IFF utility

was integral to the CITV, where only the vehicle commander could use it. Had the IFF been ported to the GPS/GPSE, the gunner would have had the benefit of the automated system, without having to rely on the commander for an independent reading.

Other aspects of the protection dynamic were not stressed in the battalion evaluation. For example, mobility and countermobility operations were represented in notional form only. Operational security was oversimplified as well. Finally, the OPFOR held tightly to its programmed routes, and was not allowed to deviate in order to exploit a possible BLUFOR weakness.

Leadership. The importance of effective leadership was demonstrated throughout the CVCC effort. While there was no intent to grade participants that assumed the role of battalion commander, there were observable differences in performance that transcended the presence or absence of CVCC equipment. Among both type units, there were individuals that seemed to interpret the tactical situation and employ their resources more effectively than others to accomplish the mission. The CVCC system provided the commander a set of tools that enabled him and his unit to accomplish certain functions more quickly and more effectively.

Summary of Findings

Within the command and control functional area, the CVCC system provided participants the ability to transmit more comprehensive intelligence reports on a wider basis, and to maintain a more accurate picture of their own unit status. Furthermore, CVCC units were able to receive, analyze, and transmit FRAGOs more efficiently, enhancing the unit's agility and synchronization. Additional CVCC capabilities that were not measured within this evaluation provide promising aids to tactical planning processes across the combined arms spectrum, to include the integration of CS and CSS planning.

Within the maneuver functional area, CVCC units moved faster and used a larger portion of the battlefield than did Baseline units, acquired the enemy at greater ranges, and maintained positions of advantage more effectively to achieve better loss-exchange ratios in both Stages 1 and 2 (delay and counterattack). CVCC crews engaged the OPFOR at consistently greater ranges on average, and although they did not achieve the same hit rates as Baseline crews, they did achieve a significantly higher kill rate among hits scored. Advantages in target engagement performance attributed to the CITV in prior research (e.g., Quinkert, 1990), and more substantial advantages demonstrated for POSNAV and CVCC by Du Bois and Smith (1989) and Leibrecht et al. (1992) and reinforced in the current evaluation clearly highlight the improved potential of a CVCC-equipped battalion or task force across all maneuver functions.

Within the fire support and intelligence systems, CVCC units consistently reported enemy locations and activities more accurately than Baseline units. Furthermore, CVCC enhanced the unit's ability to identify targets of opportunity, as evidenced by the six-fold increase in CFFs sent. As a result of improved reporting, indirect fires could be targeted and synchronized more effectively, and a more accurate enemy situation could be developed, to enhance the unit's situational awareness.

In summary, the CVCC system provides the commander a better view of the battlefield, and enables the unit to move faster, strike harder, and finish the enemy sooner than a conventionally equipped unit. It affords the staff more time to coordinate, integrate, and synchronize the commander's orders and directives.

These findings demonstrate the benefits that can be achieved using enhanced sensors (i.e., the CITV) and automated C^2 technology in one specific type combat vehicle (i.e., a CVCC equipped tank unit), with a compatible automated system (i.e., the CVCC TOC workstation) in the combat unit's TOC. The findings also suggest implications for expanding and integrating an automated C^2 system to different combat and combat support units, such as mechanized infantry, combat engineers, air defense, intelligence, and artillery. The CVCC battalion evaluation, therefore, provides the basis for the continued research and development of automated C^3 systems throughout the combined arms team.

Conclusions

Based on the performance of tank battalions in the simulated combat environment of the MWTB, the findings of the evaluation support the conclusions shown in Table 28.

The reader should bear in mind these conclusions are based on the performance of tank battalions operating in the distributed interactive simulation environment. Inherent in the experimental design and methodology were a number of limitations (discussed earlier in this report) which form an important part of the context for the evaluation's conclusions.

Recommendations for Future Research

The recommendations contained in this section include primarily methodological suggestions and developmental initiatives to further the application of digital command and control systems similar to those employed in the CVCC program. Selected equipment-based recommendations are also highlighted, where appropriate. Where used in this section, the terms "CVCC," or "CVCC system" applies to the integrated array of improved thermal technologies, and digital reporting technologies.

The overall CVCC research program, from the individual tank level tests of the CITV and prototype POSNAV system (Quinkert,

Table 28

Summary of Conclusions from the CVCC Battalion Evaluation

Command and Control

- CVCC units received more comprehensive FRAGOs in far less time than required within Baseline units. Furthermore, digital FRAGOs were more easily interpreted, resulting in notably fewer requests for clarification.
- Digital message formats enabled CVCC units to relay more comprehensive enemy information from external sources to subordinate elements, in less time than among Baseline units.
- The tactical display of POSNAV data (position and operational status) enabled CVCC units to maintain their own unit status in a more accurate and timely fashion than Baseline units.
- CVCC units were able to accomplish all tactical missions with a significant reduction in their voice radio signature, resulting in greater access to voice radio networks.
- As a result of enhanced friendly and enemy situation data, CVCC commanders and staff had the tools available to maintain a more accurate assessment of the overall tactical situation.

Maneuver

- CVCC units moved further, in less time than Baseline units, to maintain more effective stand-off ranges during tactical engagements. This permitted CVCC units to complete tactical missions in less time than Baseline units.
- The hunter-killer advantage of the CITV enabled CVCC units to acquire targets sooner and at greater ranges than Baseline units. CVCC units also achieved better kill per hit ratios than Baseline units, suffered fewer losses, and achieved better losses per kill ratios in the counterattack.
- Overall, CVCC units demonstrated greater agility and synchronization than Baseline units.
- CVCC command vehicle crews were able to engage the OPFOR as effectively as their Baseline counterparts, indicating that the C^2 requirements associated with the CVCC system do not inhibit the crew's ability to fight the tank.
- The IFF capability integrated into the CITV in the CVCC system did not prevent fratricide events, and should be a subject of further study. This effect may be attributed to the combined result of unrealistic expectations regarding the IFF's reliability and its implementation in other than the primary direct fire control system.
- CVCC units demonstrated greater apparent freedom of movement.

Fire Support

- CVCC units generated more accurate CFFs than Baseline units.
- CVCC calls for fire contained a greater volume of useful information.

Intelligence

- CVCC units generated more accurate CONTACT and SPOT reports than Baseline units.
- CVCC units generated a greater volume of useful information in CONTACT and SPOT reports.

1990, Du Bois and Smith, 1989) through the current evaluation, has demonstrated several operational advantages attributable to enhanced battlefield sensors (i.e., the CITV) and automated digital communications on the tank platform. In addition to CVCC research findings, lessons learned from the Battlefield Synchronization Demonstration in December, 1992 and March 1993 (see Courtright et al., 1993, and Goodman, 1993) provide a basis

for an investigation of applications across the entire combined arms team. It is recommended that CVCC technology be integrated among infantry, armor, aviation, engineer, air defense, battlefield surveillance, and artillery systems, and that the entire force be linked thru TOC workstations, to further develop hardware and software specifications, as well as employment techniques, at the brigade and division level.

Another important aspect of future research should be an investigation of integrating conventional systems with advanced capabilities, as well as the integration of non-compatible technologies. For example, the impact of fielding an advanced, automated C^2 capability in only selected combat vehicles should be investigated. That is, assuming that the full sensor and C^2 suite could only be purchased for a portion of an existing combat vehicle fleet, is it preferable to outfit only selected units throughout the field army, or to establish priorities for key command vehicles (e.g.: battalion commander and S3, TOC, company commanders and XOs, platoon leaders)?

Additionally, assuming that cargo and utility vehicles within a combat unit do not have digital position reporting capabilities, the potential affect on unit sustainment of global positioning system applications versus conventional navigation tools should be determined.

Although only a small number of fratricide events occurred in either condition during the battalion evaluation, and the data are inconclusive, integrating an IFF capability into the CITV did not appear to prevent fratricide. Further research of an integrated system, possibly linked to the gunner's primary fire controls, is clearly indicated.

The provision of the concept of operations module in the TOC workstations was a useful planning tool. However, since the module could only demonstrate BLUFOR actions, OPFOR reactions and counteractions had to be visualized and demosntrated in other ways. It is recommended that the concept of operations overlay tool be modified to incorporate possible enemy actions.

Up to and through the battalion evaluation, the tactical planning process was truncated in order to focus on tactical operations. We recommend that future investigations extend the planning responsibilities of participating units to increase ownership over the tactical operation, and to evaluate TOC operations to:

(a) Study parallel planning techniques using CVCC.

(b) Develop information management techniques within the TOC.

(c) Identify critical staff functions and techniques or procedures to accomplish those tasks.

(d) Determine the impact of commander's critical information requirements (CCIR) on CVCC supported operations.

(e) Develop command post and TOC standing operating procedures (SOPs), e.g., staff synergy, vertical and horizontal synchronization.

(f) Evaluate the integration of digital communications between targeting systems and fire support elements.

The CVCC system demonstrated many potential advantages of both automated C^2 systems and enhanced battlefield sensors. However, the full impact of these technological enhancements can only be fully demonstrated through additional applications and tests in both computer-based, man-in-the-loop simulation, and field trials.

References

Association of the United States Army (1992). Army Weapons. Army (October), 231-303.

Atwood, N. K., Winsch, B. J., Sawyer, A. R., & Ford, L. A. (in preparation). Training and soldier machine interface for the combat vehicle command and control system (ARI Technical Report). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences.

Communications and Electronics Command (1987). SINCGARS Staff Planning Guide: First Article and 1st Year Production Radio Versions (Draft). Fort Monmouth, NJ: Author.

Courtright, J. F., Winsch, B. J., Ford, L. A., Leibrecht, B. C., Sever, R. S., & Meade, G. A. (1993). Combined arms demonstration of digitized command and control using distributed interactive simulation (Technical Report # ADST/WDL/TR-93-003041). Fort Knox, KY: Mounted Warfighting Battlespace Laboratory.

Department of Defense (1992). Final Report to Congress: Conduct of the Persian Gulf war. Washington, DC: Author.

Department of the Army (1985). National Training Center Commander's Memorandum. Fort Irwin, CA: Headquarters, National Training Center and Fort Irwin.

Department of the Army (1988a). Army Training and Evaluation Plan No. 71-2-MTP: Mission Training Plan for the Tank and Mechanized Infantry Battalion Task Force. Fort Benning, GA: U.S. Army Infantry School.

Department of the Army (1988b). Field Manual No. 6-20: Fire Support in Combined Arms Operations. Washington, DC: Headquarters, Department of the Army.

Department of the Army (1988c). Field Manual No. 71-2: The Tank and Mechanized Infantry Battalion Task Force. Washington, DC: Headquarters, Department of the Army.

Department of the Army (1988d). Field Manual No. 71-3: Armored and Mechanized Infantry Brigade. Washington, DC: Headquarters, Department of the Army.

Department of the Army (1990a). Field Manual No. 6-20-40: Tactics, Techniques and Procedures for Fire Support for Brigade Operations (Heavy). Washington, DC: Headquarters, Department of the Army.

Department of the Army (1990b). Special Text No. 17-17: Combined Arms Heavy Battalion/Task Force Standard Operating Procedures. Fort Knox, KY: U.S. Army Armor School.

Department of the Army (1991a). Field Manual No. 6-20-20: Tactics, Techniques and Procedures for Fire Support at Battalion Task Force and Below. Washington, DC: Headquarters, Department of the Army.

Department of the Army (1991b). TRADOC Pamphlet 11-9: Blueprint of the Battlefield (Final Draft). Fort Monroe, VA: U.S. Army Training and Doctrine Command.

Department of the Army (1992). IVIS Operational Concept. Fort Knox, KY: U.S. Army Armor Center.

Department of the Army (1993a). Field Manual No. 100-5: Operations. Washington, DC: Headquarters, Department of the Army.

Department of the Army (1993b). Special Text No. 17-1-1: Tactics, Techniques, and Procedures for the M1A2 Company Team. Fort Knox, KY: Headquarters, U.S. Army Armor Center.

Department of the Army (in preparation). Field Manual No. 71-100-1: Armor and Mechanized Division Operations: Tactics and Techniques (Coordinating Draft). Fort Leavenworth, KS: Concepts and Doctrine Directorate, U.S. Army Command and General Staff College.

Du Bois, R. S., & Smith, P. G. (1989). A simulation-based evaluation of a position navigation system for Armor: Soldier performance, training, and functional requirements (ARI Technical Report 834). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences. (AD A210 696)

Du Bois, R. S., & Smith, P. G. (1991). A simulation-based assessment of automated command, control and communications for armor crews and platoons: The intervehicular information system (IVIS) (ARI Technical Report 918). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences. (AD A233 509)

Goodman, G. W., Jr. (1993). U.S. Army synchronizes its combat arms with digital data. Armed Forces Journal International (May), 35-26.

Leibrecht, B. C., Kerins, J. W., Ainslie, F. M., Sawyer, A. R., Childs, J. M., & Doherty, W. J. (1992). Combat vehicle command and control systems: I. Simulation-based company-level evaluation (ARI Technical Report 950). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences. (AD A251 917)

Leibrecht, B. C., Meade, G. A., Schmidt, J. H., Doherty, W. J., & Lickteig, C. W. (in preparation). Evaluation of the combat vehicle command and control system: Operational effectiveness of an armor battalion (ARI Technical Report). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences.

Leibrecht, B. C., Winsch, B. J., Ford, L. A., Sawyer, A. R., Meade, G. A., Ainslie, F. M., Smith, P. G., Sever, R. S., & Doherty, W. J. (1993). Battalion evaluation of the combat vehicle command and control system in distributed interactive simulation: Preliminary findings (ARI Technical Report 992). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences.

Lickteig, C. W., Williams, S. G., and Smart, D. L. (1992). Vertical slice battalion-level assessment of future command and control systems. Paper presented at the 34th Annual Conference of the Military Testing Association, San Diego, CA.

Meade, G. A., Fergus, K. W., Pollock, R. L., Cash, A. C., & Lozicki, R. J. (in preparation). Debriefing comments from the battalion evaluation of the Combat Vehicle Command and Control (CVCC) system (ARI working paper). Fort Knox, KY: Army Research Institute for the Behavioral and Social Sciences.

O'Brien, L. H., Wigginton, D., Morey, J. C., Leibrecht, B. C., Ainslie, F. M., & Sawyer, A. R. (1992). Combat vehicle command and control battalion-level preliminary evaluation (ARI Research Report 1627). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences. (AD A257 467)

Quinkert, K. A. (1990). Crew performance assessment associated with the simulation of the commander's independent thermal viewer (CITV) (ARI Technical Report 900). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences. (AD A226 890)

Sawyer, A. R., Meade, G. A., Ainslie, F. M., & Leibrecht, B. C. (in preparation). Support package for the battalion evaluation of the Combat Vehicle Command and Control (CVCC) system (ARI working paper). Fort Knox, KY: Army Research Institute for the Behavioral and Social Sciences.

Smith, P. G. (1990). SIMNET combat vehicle command and control (CVC2) system user's guide (BBN Technical Report 7323). Fort Knox, KY: Bolt Beranek and Newman, Inc.

U. S. Army Armor School (1987). M1 SIMNET Operator's Guide. Fort Knox, KY: Headquarters, U. S. Army Armor School.

U.S. Army Armor School (1989). SIMNET User's Guide. Fort Knox, KY: Headquarters, U. S. Army Armor School.

Appendix A

Glossary

AA	Avenue of Approach
ACR	Armored Cavalry Regiment
AD	Armor Division
ADA	Air Defense Artillery
AFATDS	Advanced field artillery tactical data system
ALO	Air liaison officer
AMMO	Ammunition status (report)
AOAC	Armor Officer Advanced Course
AOBC	Armor Officer Basic Course
ATTCS	Army tactical command and control system
AR	Armor
ARI	U.S. Army Research Institute for the Behavioral and Social Sciences
Arty	Artillery
ASP	Ammunition supply point
Asst	Assistant
ATCCS	Army tactical command and control system
ATHS	Airborne target handover system
Atk	Attack
B/prep	Be prepared
BAI	Battlefield air interdiction
BDE, Bde	Brigade
Bdy	Boundary
BHL	Battle handover line
BHO	Battle handover
BLUFOR	Friendly (Blue) forces. NOTE: Includes all friendly manned vehicles (simulators), SAFOR, MCC-generated units, and notional units.
Bn	Battalion
BOS	Battlefield operating system
BP	Battle position
BSA	Brigade support area
BSD	Battlefield Synchronization Demonstration
C2	Command and control
C3	Command, control and communications
$C3_{CM}$	Command, control and communications countermeasures
C&J	Collection and jamming
CAA	Combined arms army
CAS	Close air support
CAS3	Combined Arms and Services Staff School
CATK	Counterattack
CCD	Command and control display
CCIR	Commaner's critical information requirements
Cdr	Commander
CFF	Call for fire

CFL	Coordinated fire line
CGSC	Command and General Staff College
cGy	Centigray
CITV	Commander's independent thermal viewer
Cmd Grp	Command Group
Co	Company
COFT	Conduct of Fire Trainer
CoM	Center of mass
CONTACT	Contact (report)
CP	Check point or command post
CPX	Command post exercise
CRP	Combat reconnaissance patrol
CS	Combat support
CSR	Controlled supply rate
CSS	Combat service support
CVCC	Combat vehicle command and control
CWS	Commander's weapon station
DAG	Divisional Artillery Group
DCA	Data collection and analysis
DECON	Decontaminate or decontamination
Def	Defend
DIS	Distributed interactive simulation
Div	Division
DS	Direct support
DSA	Division support area
E	East
EA	Engagement area
Ech	Echelon
ECR	Exercise control room
Eff	Effective
En	Enemy
ENGR	Engineer
EPW	Enemy prisoner of war
ETA	Estimated time of arrival
FA	Field Artillery
FASCAM	Family of scatterable mines
FBC	Future Battlefield Conditions
FDC	Fire direction center
FEBA	Forward edge of the battle area
FIST	Fire support team
FO	Forward observer
FLOT	Forward line of own troops
FPF	Final protective fires
FRAGO	Fragmentary order
FS	Fire support
FSB	Forward support battalion
FSCL	Fire support coordination line
FSE	Fire support element
FSO	Fire support officer
FUEL	Fuel status (report)

GAS	Gunner's auxiliary sight
GLOS	Gun line of sight
GMRD	Guards motorized rifle division
GMRR	Guards motorized rifle regiment
GPS	Gunner's primary sight
GPSE	Gunner's primary sight extension
GSR	Ground surveillance radar
GTD	Guards tank division
GTR	Guards tank regiment
HEAT	High explosive, anti-tank
Hr	Hour
HV MORT, Hvy Mort	Heavy mortar
ID	Infantry division
IDM	Improved data modem
IFF	Identification, friend or foe
IN	Infantry
INTEL	Intelligence (report)
IR	Infrared
IVIS	Intervehicular information system
L	Left
LAN	Local area network
LD	Line of departure
LOSAT	Line of sight anti-tank
LRF	Laser range finder
MCC	Management command and control
MCS	Maneuver Control System
MECH	Mechanized Infantry
MI	Military Intelligence
MLRS	Multiple launch rocket system
MOPP	Mission oriented protective posture
MOS	Military occupational specialty
MOU	Memorandum of understanding
MP	Military Police
MRB	Motorized rifle battalion
MRB+	Motorized rifle battalion, reinforced
MRC	Motorized rifle company
MRC+	Motorized rifle company, reinforced
MRD	Motorized rifle division
MRP	Motorized rifle platoon
MRR	Motorized rifle regiment
MRS	Muzzle reference system
MSR	Main supply route
MST	Maintenance support team
MWTB	Mounted Warfare Test Bed
(M)	Mechanized
N	North
<u>n</u>	Number of observations (data points) used in

	statistical analysis
NAI	Named area of interest
NBC	Nuclear, biological and chemical
NLT	No later than
NTC	National Training Center
NW	Northwest
O&I	Operations and intelligence
O/L	Overlay
O/O	On order
OBJ	Objective
OEG	Operational exposure guidance
OPCON	Operational control
OPFOR	Opposing forces
Ops, Opns	Operations
OPORD	Operations order
PIR	Priority intelligence requirement
PL	Phase line
PLD	Probable line of deployment
PLDC	Primary Leadership Development Course
Plt	Platoon
POF	Priority of fires
POSNAV	Position/Navigation
PP	Passage point
Prep	Prepare
PVD	Plan view display
R	Right
RA	Research assistant
RAG	Regimental Artillery Group
Recon	Reconnaissance
REDCON	Readiness condition
Regt	Regiment
Reinf	Reinforce
Res	Reserve
RSR	Required supply rate
RSTA	Reconnaissance, surveillance and target acquisition
S	South
SAFOR	Semiautomated forces
Sct	Scout
SE	Southeast
SHELL	Shell (report)
SIMNET	Simulation networking
SINCGARS	Single channel ground-air radio system
SitDisplay	Situation and planning display
SITREP	Situation report
SMI	Soldier-machine interface
SMK	Smoke
SOI	Signal operating ins.ructions
SOP	Standard operating procedure
SPOT	Spot (report)

Spt	Support
SP	Self-propelled
STX	Situational training exercise
SW	Southwest
TAC	Tactical command post
TACFIRE	Tactical fire direction system
TACOM	U.S. Army Tank-Automotive Command
TAF	Tactical Air Force
TAI	Target area of interest
TBD	To be determined
TC	Tank Commander
TCP	Traffic control point
TF	Task force
TIS	Thermal imaging system
Tns	Trains
TO&E	Table of organization and equipment
TOC	Tactical operations center
TR	Tank regiment
TRADOC	Training and Docrine Command
TRP	Target reference point
TTP	Tactics, techniques and procedures
USAARMS	U.S. Army Armor School
V/S	Vulcan/Stinger
Vic	Vicinity
W	West
XO	Executive Officer

APPENDIX B

Selected Participant Biographical Data

Table B-1

Participants' Service Experience (in Years)

	Officers		NCO/Enlisted	
	CVCC	Baseline	CVCC	Baseline
Active Duty	6.16 (4.41) *n*=47	6.63 (4.13) *n*=48	4.73 (3.84) *n*=92	7.06 (5.00) *n*=96
In Armor units	3.93 (2.58) *n*=47	4.49 (2.61) *n*=48	4.36 (3.24) *n*=92	6.06 (4.37) *n*=95
In M1 units	1.80 (1.15) *n*=37	2.03 (1.27) *n*=38	2.98 (1.86) *n*=91	3.79 (3.07) *n*=89
In M60 units	1.98 (2.66) *n*=26	2.45 (1.99) *n*=26	2.82 (3.23) *n*=35	4.56 (3.90) *n*=48

Note. Each data cell includes the mean, standard deviation (in parentheses) and number of respondents (*n*).
Experience levels among Baseline NCOs are significantly higher than among CVCC NCOs.

Table B-2

Participants' Experience in Selected Positions, in Total Man-years

Duty Position	CVCC	Baseline
Officers		
Battalion commander	-- n=0	-- n=0
Battalion XO	1.16 n=2	-- n=0
Battalion S3	9.8 n=10	4.52 n=4
Battalion S2	-- n=0	0.50 n=1
Other battalion staff	18.45 n=15	19.95 n=21
Company commander	20.02 n=14	20.96 n=16
Company XO	27.60 n=24	36.16 n=32
Platoon leader	64.24 n=44	51.25 n=41
NCO/Enlisted		
Platoon sergeant	7.02 n=6	30.42 n=18
Tank commander	53.97 n=21	173.8 n=44
Gunner	119.28 n=56	182.0 n=65
Driver	152.25 n=87	141.96 n=78

Note. Table includes multiple responses from individual respondents. E.g., an officer with experience as a platoon leader, XO and company commander would have reported their tenure in each duty position.
Cell entries include total man-years, and number of respondents experienced in that duty position (n).

Table B-3

Participants' Military Schooling Level (Schools Completed)

Military School	CVCC		Baseline	
	f	%	*f*	%
Officers				
Command & General Staff Officer Course (CGSOC)	3	6.4	3	6.3
Combined Arms and Services Staff School (CAS3)	6	12.8	14	29.2
Armor Officer Advance Course (AOAC)	22	46.8	27	56.3
Armor Officer Basic Course (AOBC)	46	97.9	48	100
NCO/Enlisted				
Advanced NCO Course (ANCOC)	3	3.3	17	17.7
Basic NCO Course (BNCOC)	19	20.7	46	47.9
Primary Leadership Development Course (PLDC)	38	41.3	59	61.5

Note. Table includes multiple responses from individual respondents. E.g., a CAS3 graduate will most likely have also graduated from AOAC and AOBC.
f = frequency.
NCOs among the Baseline group have completed a significantly higher number of advanced military schools than NCOs among the CVCC group.

APPENDIX C

Operations Orders and Fragmentary Orders
Delay Test Scenario

OPORDs to support the Delay Scenario were developed for the Brigade, Battalion, and each subordinate Company. The Brigade and Battalion level orders are reproduced in this appendix. The company orders are omitted to conserve space, but the mission and commander's intent statements from each are included. Brigade and Battalion FRAGOs were also produced for both the Baseline and CVCC condition.

CVCC FRAGOs were published as overlays with integrated text messages. Only the text messages are included here. Within the scenario, a hard copy of the Brigade FRAGO with overlay was received at the Battalion TOC when the oral FRAGO was transmitted over the Brigade command network. Therefore, both the hardcopy and oral text are included. At the battalion level, however, the executive officer could only publish an oral FRAGO, given the distance between the TOC and units, and the time available in the tactical situation.

Copy __ of __ Copies
1ST Bde,23 AD
ES872023
__0400R ___ 9_

OPORD 20

Reference: Map Series V753, V751 Kentucky - Indiana, Sheets M3753 I, II, III, IV; M3760 II, III Edition 1-AMS, 1:50,000.

Time Zone Used Throughout Order: ROMEO

Task Organization

1-10 AR
- 1/A/1-440 ADA (DS)

1-92 IN (M)
- 2/A/1-440 ADA (DS)

1-91 IN (M)

BDE CONTROL
- 1-50 FA (DS)
- A/1-440 ADA (-) (V/S) (DS)
- A/23 ENGR BN (OPCON)
- 1/A/23 MI BN (C&J) (DS)
- 1/1/B/23 MI BN (GSR)
- 2/1/B/23 MI BN (GSR)
- 1/23 MP CO
- 1ST FSB (DS)

BDE TNS
- 45TH CHEM CO (SMK/DECON)(-) (DS)
- 2/48TH CHEM CO (SMK) (-) OPCON

1. SITUATION

a. Enemy Forces. Annex A (Intelligence Overlay)

(1) Overview. The 8th CAA has been attacking for the last 24 hours from SE to NW along the Elizabethtown-Brandenburg axis. The 52 ID(M) has stopped the first echelon divisions, the 4th MRD on the west and the 17th MRD on the east, just south of Elizabethtown. The commitment of the second echelon divisions of the 8th CAA has forced the withdrawal of the 52 ID(M). These second echelon divisions, the 39th GMRD on the east and the 1st GTD on the west, are currently pursuing the 52d ID(M). Expect to find elements of the 39th GMRD in the brigade's sector.

(2) Composition and Disposition. The 39th GMRD first echelon consists of the 140th GMRR on our right and the 144th

GMRR on our left. The second echelon is expected to be the 79th GTR on our right and the 146th GMRR on our left. The 39th GMRD is equipped with BMP-2s and T-80s. The 140th and 144th are currently located vic ES850580 to FS020600 and are estimated at 90% strength. The 146th GMRR and 79th GTR are estimated at 95% strength.

(3) Most Probable Course of Action. The 8th CAA will continue to attack for the next 24-36 hours to secure crossings sites over the Ohio River in order to pass the 18th CAA through to continue the attack north. The 39th GMRD will continue to attack along the Elizabethtown-Brandenburg axis for the next 24 hours and attempt to seize crossing sites vic ET730070. The enemy main effort will most likely be the center portion of our sector west of Otter Creek.

b. Friendly Forces.

(1) (Higher) 23 AD defends in sector NLT __0950R ___ 9_ to destroy the enemy second echelon divisions of the 8th CAA, the 39th GMRD (L) and 1st GTD (R). O/O counterattacks to destroy enemy elements in sector. The Division Commander's intent for is to cover the deployment of the Division's mai- defense vicinity PL TRUMP with elements of two brigades, and draw the 8th CAA's 2nd echelon into a vulnerable position where the division can counterattack to complete the destruction of the 39th GMRD and 1st GTD.

(2) (L) 210 ACR delays in sector on the Corps eastern flank.

(3) (R) 3d Bde, 23 AD delays in sector from __0950R ___ 9_ to __1350R ___ 9_ to destroy the enemy's 1st echelon regiments, forcing deployment of second echelon regiments.

(4) (Front) 1st Bde, 52 IN (M) conducts a withdrawal and battle handover at PL KING, and executes a rearward passage of lines NLT 101400 OCT 04.

(5) (Rear) 2d Bde initially Div reserve. O/O becomes Div main effort and counterattacks south to destroy enemy elements in sector.

(6) 1-50 FA DS to 1st Bde.

c. Attachments and Detachments. See Task Organization.

2. MISSION

1st Bde 23rd AD accepts battle handover from and assists with the rearward passage of lines and 52 ID (M) NLT __0950R ___ 9_. 1st Bde delays in sector from __0950R ___ 9_ to __1350R ___ 9_ to destroy the first echelon regiments of the 39th GMRD.

3. EXECUTION

a. Concept of the Operation. Annex B (Operations Overlay). 1st Bde establishes contact points south of PL KING to assist rearward passage of 1st Bde, 52d IN (M). Once the rearward passage is complete, we will delay in sector, destroy the 1st echelon regiments, and force the deployment of the enemy second echelon regiments prior to PL TRUMP, creating the preconditions for a counterattack by the 2d Bde, 23 AD. The deep battle will be fought with air interdiction and MLRS, to delay the second echelon regiments until the lead echelons can be defeated.

(1) Maneuver. My intent is to hit the enemy hard at the Battle Handover Line (PL KING), disrupt his pursuit, and destroy the leading companies of his first echelon regiments. 1-10 AR will defend in sector on the east, 1-92 IN (M) on the west, and 1-91 IN (M) in reserve. We will then delay to vic PL CLUB in order to determine the enemy's main effort. The enemy's main effort is expected to be in the 1-10 AR sector, parallel to Otter Creek. As 1-10 AR delays, 1-92 IN (M) will withdraw to maintain an orderly delay and preclude a deep penetration in the bde sector. As our battalions displace throughout the Bde sector, I plan to keep constant contact with the enemy while avoiding decisive engagement. Since the division plans to launch a major counter attack with the 2d Bde, I see few opportunities to shape the battlefield for a bde counterattack. However, we should be alert for opportunities to conduct limited counterattacks against an exposed flank or isolated units. I plan to accomplish this by conducting a delay in sector in three phases.

Phase I. Overwatch the BHL with two battalions, accept the battle handover from 1st Bde, 52 ID, and assist as 1st Bde conducts a rearward passage of lines through our sector. Hit the enemy hard at PL KING, then continue to destroy his units as we delay between PL KING and PL CLUB.

Phase II. Continue the orderly delay between PL CLUB and PL SPADE. By PL SPADE, the second echelon enemy battalions must be committed and heavily damaged.

Phase III. Continue to hit the enemy while delaying between PL SPADE and PL TRUMP. We must force the commitment of the second echelon regiments prior to PL TRUMP. O/O conduct BHO and rearward passage of lines through 1-91 IN (M) and 3-4 AR at PL TRUMP.

(2) Fires. Annex C (Fire Support).

(a) 1st Bde has priority of fires within division. CAS and MLRS will be targeted against the 39th GMRD's follow-on echelons as the Brigade's deep battle. Conventional artillery will support the close battle.

(b) POF (FA) Phase I--1-10 AR, 1-92 IN (M), 1-91 IN (M); Phase I--1-10 AR, 1-92 IN (M), 1-91 IN (M); Phase III--1-91 IN (M).

(c) Bde has six FASCAMS available. Bde Cdr is approving authority.

(3) Obstacles, Mines, and Fortifications. Annex D (Barrier Overlay).

(a) Priority of Support. 1-10 AR, 1-92 IN (M), 1-91 IN (M).

(b) Priority of Effort. Countermobility, survivability, mobility.

(c) Upon commitment of Reserve, priority of support shifts to 1-91 IN (M), and priority of effort to mobility.

(4) Counterair Operations. Annex E (Air Defense). (Omitted). Priority of protection: 1-91 IN (M), Main CP, 1-10 AR, 1-92 IN (M).

(5) Intelligence. Annex A (Intelligence).

b. 1-10 AR

(1) Prepare to delay in sector from __0950R ___ 9_ until __1350R ___ 9_.

(2) Eastern boundary ES975800. Western boundary ES860770.

(3) Man Bde contact points in sector.

(4) Support TF 1-2, 1st Bde, 52 ID rearward passage of lines and battle handover at PL KING in sector.

(5) Coordinate with 1-91 IN (M) for rearward passage of lines and battle handover thru PPs 11, 12, 13, 15, 17, and 18.

(6) Provide guides for all passage lanes in sector.

(7) O/O conduct rearward passage of lines and battle handover with 1-91 IN (M).

(8) Maintain one company reserve and do not commit without Bde approval.

c. 1-92 IN (M)

(1) Prepare to delay in sector from __0950R ___ 9_ until __1350R ___ 9_.

(2) Eastern boundary ES860770. Western boundary ES703733.

(3) Man Bde contact points in sector.

(4) Support TF 1-77, 1st Bde, 52 ID rearward passage of lines and battle handover at PL KING in sector.

(5) Provide guides for all passage lanes in sector.

(6) Coordinate with 3-4 AR, 3d Bde for rearward passage of lines and battle handover thru PPs 21, 23, 26, and 28.

(7) O/O conduct rearward passage of lines and battle handover thru 3-4 AR, 3d Bde.

d. MP.

(1) Process EPWS.

(2) Guard BSA.

(3) Provide TCPs along MSRs.

e. Reserve: 1-91 IN (M).

(1) Prepare defensive positions vic. PL TRUMP NLT __0950R ___ 9_.

(2) Eastern boundary ES790930. Western boundary ES922994.

(3) Be prepared to counterattack south.

(4) Provide guides for all passage lanes.

(5) Be prepared to assist 2d Bde, 23 AD in forward passage of lines.

f. Coordinating Instructions.

(1) PIR:

(a) Concentrations of ten or more tanks.

(b) Use of Chemical munitions.

(c) Use of airmobile opns.

(d) Report penetration of CO size or greater at all PLs.

(e) Report changes in enemy equipment, uniforms, formations, etc. which would indicate commitment of second echelons.

(2) MOPP: 1 in effect NLT __0945R ___ 9_.

(3) OEG: 70 cGy Report 50 cGy.

(4) Air Defense Warning -- Yellow.

(5) Weapons Control Status -- Tight.

(6) Other Reporting Requirements:

(a) Report battle handover complete.

(b) Report initial enemy contact.

(c) Report crossing PLs.

(d) Report Passage of Lines complete.

(7) Recognition symbol for rearward passage of lines is orange panel marker front of vehicle during the day -- red flashlight at night.

4. SERVICE SUPPORT. Annex G (Service Support). (Omitted)

5. COMMAND AND SIGNAL.

a. Command.

(1) Succession of Command: SOP.

(2) Division Main CP located vic ET568140.

(3) Brigade Main CP located vic ET872023.

(4) Division TAC located vic ET624035.

(5) Brigade TAC located vic ES877947.

(6) Division rear CP located vic ET681207.

(7) Division alternate CP is DSA ET440280.

(8) Brigade alternate CP is Bde Tns ET785227.

b. Signal.

(1) SOI index ALPHA in effect.

(2) Radio listening silence in effect __0930R ___ 9_ until first contact is reported or passage of lines is completed.

ACKNOWLEDGE:

OFFICIAL:

KNOX
Cdr

TANK
S3

Annexes: A--Intelligence
B--Operations Overlay
C--Fire Support
D--Barrier Overlay
E--Air Defense (Omitted)
F--Engineer Barrier Overlay
G--Service Support (Omitted)

ANNEX A (INTELLIGENCE) TO OPORD 20

REFERENCE: Map Series V753, V751 Kentucky - Indiana, Sheets M3753 I, II, III, IV; M3760 II, III Edition 1-AMS, 1:50,000.

Time Zone Used Throughout Order: ROMEO

1. SUMMARY OF ENEMY SITUATION

a. Para 1a, OPORD 20.

b. See current INTSUM and Appendix 1 (Situation Overlay).

c. The enemy can conduct extended air/ground operations in the 1st Bde sector with the following assets:

(1) Hip/Hoplite with IR sensors.

(2) Divisional Recon Bn.

(3) Four regimental recon companies.

d. The consolidation and subsequent movement of forces in sector indicate continued attack on the Elizabetown-Brandenburg axis.

e. Enemy in the division sector are the 1st GTD and the 39th GMRD, second echelon divisions of the 8th CAA. These divisions were recently committed after the 52d IN (M) stopped the two leading divisions, the 4th GMRD and the 17th GMRD. Forward elements and advance guard will probably attempt to hold critical terrain and assist follow-on battalions to break through or bypass our forces to secure crossing sites over the Ohio River. 1st Bde will face the 39th GMRD.

f. Elements of the 39th GMRD are moving to attack forward elements of the 1st Bde, 23 AD. Time of attack is estimated at __0950R ___ 9_. First echelon units are tentatively identified as the 140th GMRR (on our right) and the 144th GMRR (to our front), followed by the second echelon regiments, 79th GTR (R) and the 146th GMRR (L).

g. The 39th is equipped with BMP-2s and T-80 tanks. There are unconfirmed reports that the 79th GTR may have been upgraded to T-80 U tanks. The MRRs are doctrinally organized and can be expected to task organize their MRBs consistent with standard threat doctrine. The 1st brigade can expect three MRRs to

attack, each with two MRB(+) in the first echelon and one in the second echelon.

h. Within each of the MRBs, expect to see three MRCs, augmented with four (4) tanks each from the tank company. The MRBs will also approach two (2) up and one (1) back.

i. Air superiority (initially) to enemy forces.

j. Most likely chemical attack is H + 40/60.

2. ESSENTIAL ELEMENTS OF INFORMATION

a. Where will the 39th GMRD attempt its main breakthrough?

b. What is the direction of attack and what are the immediate objectives?

c. Will the enemy employ chemical or nuclear weapons? If so, when and where?

d. Where are the RAGs and DAG located?

e. Where are locations of enemy battalion and larger CPs?

3. INTELLIGENCE ACQUISITION TASKS

a. Orders to Subordinate and Attached Units.

(1) Priority Intelligence Requirements. Para 3h (1) (Coordinating Instructions), OPORD 20.

(2) 1-10 AR, 1-92 IN (M), and 1-91 IN (M) report as obtained:

(a) Size, location, direction of movement, disposition, unit identification, composition, and type of equipment of enemy units in contact.

(b) Enemy jamming activity.

(c) All enemy helicopters flying nap-of-the-earth by DTG, direction, location, and type of aircraft.

(d) All locations of enemy artillery units acquired through counterfire surveillance. Priority to self-propelled artillery.

(2) 1-50 FA. Direction of enemy artillery fire.

(3) A/1-440 ADA. Report type, location, and activity of all enemy aircraft.

(4) 1/23 MP.

(a) Report attempted enemy subversion of local population and officials.

(b) Interrogation priority: enemy unit location, direction of attack, intentions, activities, identifications, and strengths.

b. Requests to Higher, Adjacent, and Cooperating Units.

(1) 23d AD is requested to provide as obtained:

(a) Location, size, type of unit in vic of 3d Bde boundary.

(b) Type of unit, time, and direction of movement of air or surface traffic toward the 1st Bde sector.

(c) Location and direction of fire of all enemy artillery.

(2) 210 ACR is requested to provide as obtained:

(a) Location, size, type of unit in vic of Bde boundary.

(b) Enemy activity and direction of movement of air or surface traffic toward the 1st Bde sector.

5. MEASURES FOR HANDLING PERSONNEL, DOCUMENTS AND MATERIEL

Omitted

6. DOCUMENTS AND/OR EQUIPMENT REQUIRED

Omitted

7. REPORTS AND DISTRIBUTION

SOP except as modified in paragraph 4.

Acknowledge:

Appendix 1 -- Approach Overlay/NAI (Omitted)

ANNEX C (Fire Support) to OPORD 20

REFERENCE: Map Series V753, V751 Kentucky - Indiana, Sheets M3753 I, II, III, IV; M3760 II, III Edition 1-AMS, 1:50,000.

Time Zone Used Throughout Order: ROMEO

1. SITUATION

a. Enemy Forces. Para 1a, OPORD 20 and Annex A (Intelligence) to OPORD 20.

b. Friendly Forces. Para 1b, OPORD 20.

c. Attachments and Detachments. See Task Organization.

2. MISSION

Fire support units provide conventional, nuclear, and chemical fires in support of 1st Bde's delay in sector from __0950 ___ 9_ to __1350 ___ 9_. Provide fires in support of the rearward passage of lines and battle handoff from 52d ID(M) NLT 101400 OCT 04.

3. EXECUTION

a. Concept of the Operation. A 20 minute conventional counterpreparation will be fired by Division Artillery, on order, on completion of battle handoff and rearward passage of lines by the 52d ID(M). Groups and series of targets are planned in major choke points to slow the enemy's advance and assist friendly forces disengagement from delay positions.

b. Air Support. 9 TAF supports the brigade with 36 sorties daily. Priority to interdiction of second echelon armor concentrations of company size or greater, C3 facilities, and engineer bridging assets. Plan 4 sorties per CAS mission. Priority of employment to the Brigade deep battle and counterfire targets, in that order.

c. Chemical/Nuclear Support. See Appendix 1. (Omitted)

d. FA Support.

(1) General.

(a) Priority of Fires: Phase I/II/III: 1-10 AR, 1-92 Mech, and on order 1-91 Mech when committed to counterattack.

(b) Counterfire priorities. Enemy mortars and FA firing at lead battalions, then nuclear-capable fire systems.

(c) Close Support: C2 vehicles, BMP/BTR/Tank concentrations of platoon size or larger.

(d) Copperhead Priorities: C2 vehicles, ADA vehicles, bridging assets, RSTA assets and recon elements.

(2) Organization for Combat. 1-50 FA (155 SP) DS 1st Bde.

(3) Miscellaneous.

(a) Cdrs munitions effectiveness criteria is 10% casualties.

(b) No targets of opportunity on less than platoon size enemy armor formations.

h. Coordinating Instructions.

(1) Division FSCL is PL DEUCE upon completion of rearward passage of lines and battle handoff.

(2) Initial Bde CFL is PL DEUCE. O/O CFL is PLs KING, JACK, CLUB, and SPADE (in order).

4. SERVICE SUPPORT.

a. General. OPORD 20, para 4.

b. ASP locations --See Annex G (Omitted).

c. CSR is RSR for the next two days.

5. COMMAND AND SIGNAL.

a. Command.

(1) See OPORD for Div/Bde TOC locations.

(2) 1-50 FA TOC initial ES860890.

b. Signal.

(1) SOI index ALPHA in effect.

(2) FS nets/Bn SOP.

Acknowledge:

Appendix 1--Fire Support Overlay (Omitted)
Appendix 2--Chemical/Nuclear Support (Omitted)

Copy ___of ___Copies
1ST BDE, 23 AD
ES877947
__1024R OCT 04

FRAGO 1 to OPORD 20

Reference: No Change

Task Organization: No Change

1. SITUATION

39TH GMRD shifting course from N to NW through the 1-92 IN (M) sector. Enemy right flank is exposed and vulnerable to counterattack.

2. MISSION

On order, 1st Bde counterattacks in sector to destroy the 144th GMRR and force the deployment of 2d echelon regiments of the 39th GMRD.

3. EXECUTION

a. 1-10 AR (main effort).

(1) Counterattack on order, from BPs vicinity PL SPADE, along Axis Stingray to seize OBJ Ice (ES855826).

(2) Attack by fire into EA SHARK to destroy remnants of 144th and to prevent envelopment of 1-92 IN (M).

(3) Be prepared to withdraw to original sector if 2d echelon regiments are committed.

b. 1-92 IN (M).

(1) Establish a hasty defense vic PL CLUB and PL QUEEN to fix the enemy in support of 1-10 AR's counterattack.

(2) O/O, lift and shift fires south.

c. 1-91 IN (M).

(1) Follow 1-10 AR as Bde Reserve.

(2) O/O, counterattack thru 1-10 AR into EA SHARK (main effort, O/O).

d. Coordinating Instructions.

(1) PL QUEEN (PLD) effective on implementation. PLD may be adjusted based on progress of 1-10 AR delay in sector.

(2) Boundary change between 1-92 and 1-10 effective on implementation of this FRAGO. Bde (Div) eastern boundary change effective when elements of 1-10 are clear of proposed 210 ACR sector.

(3) Earliest time of implementation: _______ (40 min from issuance).

4. SERVICE SUPPORT. No Change.

5. COMMAND AND CONTROL

Bde Cdr currently located with 1-10 AR vic ES851947.

ACKNOWLEDGE:

OFFICIAL: KNOX
Cdr

TANK
S3

ANNEX A: FRAGO 1 OVERLAY (Omitted)

FRAGO 1 to OPORD 20 (Oral transcript for Baseline)

"GUIDONS, THIS IS NOVEMBER THREE-THREE, ORDERS, OVER."

NOTE: *YANKEE 06, MIKE 06, and DELTA 06 respond on Bde Cmd net.*

"THIS IS NOVEMBER THREE-THREE: FRAGO."

"RED AXIS SHIFTED TO NORTH WEST; RIGHT FLANK EXPOSED TO COUNTERATTACK.

"ON ORDER, 1ST BDE COUNTERATTACKS IN SECTOR TO DESTROY THE 144TH GMRR AND FORCE DEPLOYMENT OF 2ND ECHELON REGIMENTS OF THE 39TH GMRD.

"YANKEE: MAIN EFFORT: COUNTERATTACK ON ORDER FROM BRAVO-PAPAS VICINITY PHASE LINE SPADE, ALONG AXIS STINGRAY (ES865900-858856) TO SEIZE OBJ ICE (CENTER OF MASS ES855826) AND ATTACK BY FIRE INTO ENGAGEMENT AREA SHARK (CENTER OF MASS ES845810)."

"MIKE, SUPPORT YANKEE BY FIRE FROM PHASE LINES CLUB AND QUEEN."

"DELTA: BE PREPARED TO ASSUME YANKEE'S MISSION."

"NEW GRAPHICS EFFECTIVE ON ORDER, HARD COPY ENROUTE YOUR TOCS."

"YANKEE AND MIKE, YOUR BOUNDARY WILL RUN SOUTH GENERALLY ALONG THE 83 GRID LINE. YANKEE, YOUR LEFT BOUNDARY WILL SHIFT TO VICINITY THE 92 GRID WHEN YOU CLEAR THAT SECTOR."

"PROBABLE LIMA-DELTA IS PAPA-LIMA QUEEN, FROM VICINITY ES830860 - 920880. LIMA-DELTA WILL BE ADJUSTED BASED ON YANKEE'S POSITION WHEN THIS FRAGO IS IMPLEMENTED."

"BE PREPARED TO EXECUTE NO EARLIER THAN __________ (T+74 MIN)."

"BDE COMMANDER CURRENTLY WITH 1-10 AR."

"ACKNOWLEDGE, OVER."

FRAGO 1 to OPORD 20 (Text for CVCC digital overlay)

OVERLAY TEXT

FRAGO 1-20
SITUATION -Enemy axis shifted from N to NW into 1-92 IN sector to expose a flank.
MISSION -O/O 1st Bde catks in sector to destroy 2nd echelon/144th MRR and force depl of 2nd ech/39th GMRD.
EXECUTION
1-10 AR (main effort) CATK along STINGRAY to seize ICE; atk by fire into SHARK.
1-92 IN spt by fire from vic PL CLUB & QUEEN.
1-91 IN B/prep to assume main attack.
Coordination: New bdys and PL eff o/o. PLD may be adjusted when order is implemented.
COMMAND -N06 with 1-10 AR.
END

Close

Copy ___of ___Copies
1ST Bde, 23 AD
ES877947
__1115R ___ 9_

FRAGO 2 TO OPORD 20

Reference: No Change

Task Organization: No Change

1. SITUATION

a. Enemy: 2d echelon regiments of the 3 GMRD are moving NW into the Bde sector. Air interdiction has delayed the enemy arrival until _____ (thirty minutes from time this FRAGO is issued).

b. Friendly: 23 AD continues to defend in sector.

2. MISSION

On order, 1st Bde establishes defensive positions along PL ACE (83 E-W gridline), to delay enemy forces S of PL TRUMP until ________ (two hrs, thirty-five minutes from time this FRAGO is issued).

3. EXECUTION

a. Concept: Annex A, Operations Overlay. 1st Bde occupies sector along PL ACE with 1-10 AR on the left, 1-92 IN (M) on the right, and 1-91 IN(M) to the rear along PL TRUMP.

b. Subordinate Unit Tasks:

(1) 1-10 AR delays in sector from PL ACE (vic ES830830-910830) to PL TRUMP until _______ (time specified).

(2) 1-92 IN (M) delays in sector from PL ACE to PL TRUMP, until _______ (time specified).

(3) Reserve: 1-91 IN (M) re-occupies defensive positions along PL TRUMP. On order, counterattacks south to destroy enemy penetrations.

c. Coordinating Instructions: Defend on order, no later than _____ (thirty minutes from time order is issued).

4. SERVICE SUPPORT. No Change.

5. COMMAND AND CONTROL

Bn Cdr will locate to rear of 1-10 AR.

ACKNOWLEDGE:

OFFICIAL:

KNOX
Cdr

TANK
S3

ANNEX A: FRAGO 2 OVERLAY (omitted)

FRAGO 2 to OPORD 20 (Oral transcript for Baseline)

"GUIDONS, THIS IS NOVEMBER THREE-THREE, ORDERS, OVER."

NOTE: *YANKEE 06, MIKE 06, and DELTA 06 respond on Bde Cmd net.*

"THIS IS NOVEMBER THREE-THREE: FRAGO."

"SECOND ECHELON REGIMENTS OF 39th GMRD ARE APPROACHING NOVEMBER'S SECTOR. THE ENEMY ADVANCE IS DELAYED BY AIR INTERDICTION, ENEMY EXPECTED TO ARRIVE IN SECTOR NO SOONER THAN _____ *(30 min from time this FRAGO is issued)*.

"YANKEE AND MIKE: RESUME DELAY IN SECTOR FROM ACE (83 E-W GRIDLINE) ON ORDER, TO PREVENT ENEMY PENETRATION OF TRUMP UNTIL ____ *(2 hrs 35 min from time this FRAGO is issued)*.

"DELTA: RESERVE, REOCCUPY DEFENSIVE POSITIONS ALONG PL TRUMP, O/O COUNTERATTACK SOUTH TO DESTROY ENEMY PENETRATIONS."

"NEW GRAPHICS EFFECTIVE ON ORDER, HARD COPY ENROUTE YOUR TOCS."

"BE PREPARED TO EXECUTE AT ____________ *(30 MIN FROM ISSUE TIME)*."

"ACKNOWLEDGE, OVER."

FRAGO 2 to OPORD 20 (Text for CVCC digital overlay)

OVERLAY TEXT

FRAGO 2-20
SITUATION -Enemy 39th GMRD 2d Ech Regts approaching Bde sector, delayed by BAI, ETA: 30 mins.
MISSION -O/O 1st Bde delays from PL ACE to PL TRUMP until ____ (time).
EXECUTION
1st Bde delays with 1-10 AR on L, 1-92 IN on R, 1-91 IN in Res vic TRUMP.
1-91: O/O catk S to destroy en penetrations.
Coordination: defend O/O, NLT (time).
END

Close

Copy __ of __ Copies
1-10 AR, 1ST Bde, 23 AD
ES866925
__0530R ___ 9_

OPORD 200

Reference: Map Series V753, V751 Kentucky - Indiana, Sheets M3753 I, II, III, IV; M3760 II, III Edition 1-AMS, 1:50,000.

Time Zone Used Throughout Order: ROMEO

Task Organization:

A Co, 1-10 AR

B Co, 1-10 AR

C Co, 1-10 AR

D Co, 1-10 AR

Bn Control
Scout Plt
Hvy Mort Plt
1/A/1-440 ADA (V/S)(DS)

Bn Trains
MST/B/1 FSB

1. SITUATION

a. Enemy Forces. Annex A (Intelligence Overlay)

(1) Overview. The 17th MRD has been attacking for the last 24 hours from SE to NW along the Elizabethtown-Brandenburg axis. The 1st Bde, 52 ID(M) has stopped the 17th MRD, just south of Elizabethtown, and forced the commitment of the second echelon division, the 39th GMRD. The 39th GMRD has forced the withdrawal of the 1st Bde, 52 ID(M). The 39th GMRD is currently pursuing the 1st Bde, 52d ID(M). In our sector, we will most likely face elements of the 144th GMRR, and possibly the 140th GMRR, of the 39th GMRD.

(2) Composition and Disposition. The 39th GMRD is equipped with the BMP-2 and T-80. The 144th GMRR is to our front, and the 140th GMRR is to our right. The 146th GMRR is the second echelon regiment behind the 144th GMRR. The 79th GTR is the second echelon regiment behind the 140th GMRR. The 144th GMRR consists of three MRBs and one tank battalion. The MRBs will fight as task organized reinforced MRBs, according to standard threat doctrine. The 144th GMRR is currently located vic ES950580-FS020600 and is estimated at 90% strength.

(3) Most Probable Course of Action. The 144th GMRR will continue to attack NW along the Elizabethtown-Brandenburg axis and attempt to seize crossing sites over the Ohio River vic ET 730070. The enemy main effort will most likely be the right portion of our sector, west of the Otter Creek corridor. The most likely formation is two (2) MRBs (+) up and one (1) back. Each MRB can be expected to approach with two (2) MRCs (+) forward and one (1) back. All rivers in our sector are fordable and the terrain offers good cross country mobility.

b. Friendly Forces.

(1) (Higher) 1st Bde 23 AD accepts battle handover from and assists with the rearward passage of lines of 1st Bde, 52 ID (M) NLT __0950R ___ 9_. 1st Bde delays in sector from __0950R to __1350R ___ 9_ to destroy the first echelon regiments of the 39th GMRD forward of PL TRUMP. The Brigade commander's intent is to hit the enemy hard at PL KING, disrupt his pursuit, and destroy the leading companies of the lead regiments. He intends to continue the delay in depth, continuing to attrite the enemy, to force the commitment of the second echelon regiments north of PL TRUMP.

(2) (L) 210 ACR delays in sector on the Corps eastern flank.

(3) (R) 1-92 IN (M) accepts battle handover from and assists the rearward passage of lines of TF 1-77, then delays in sector from __0950R ___ 9_ to __1350R ___ 9_ to destroy the 140th GMRR south of PL TRUMP.

(4) (Front) TF 1-2, 1st Bde, 52 IN (M) conducts a withdrawal and battle handover at PL King and executes a rearward passage of lines through 1-10 AR NLT __0950R ___ 9_.

(5) 1-91 IN (M) (Bde Reserve) prepares defensive positions vic PL TRUMP NLT __0950R ___ 9_. O/O conducts counterattack south.

(6) 1-50 FA DS to 1st Bde.

(7) A/23d ENGR OPCON to 1st Bde, 23 AD.

(8) A/1-440 ADA DS to 1st Bde, 23 AD.

c. Attachments and Detachments. See Task Organization.

2. MISSION

1-10 AR accepts battle handover from, and assists in rearward passage of lines of TF 1-2 NLT __0950R ___ 9_ at PL KING. 1-10 AR delays in sector from __0950R to __1350R ___ 9_ to destroy the 144th GMRR south of PL TRUMP. O/O conducts rearward passage of lines through 1-91 IN (M).

3. EXECUTION

a. Concept of Operation. Annex B (Operations Overlay). My intent is to accept the battle from TF 1-2 at PL KING and destroy 4 reinforced motorized rifle companies at PL KING. We will then delay in sector, defending from successive company BPs, destroying the enemy without becoming decisively engaged, forcing the deployment of the 146th GMRR, the second echelon regiment following the 144th GMRR, prior to PL TRUMP.

(1) Maneuver. The battalion scouts will establish Contact Points 7, 9, 10, and 2 forward of PL KING and assist TF 1-2, 1st Bde, 52d IN (M) in their rearward passage of lines. My intent is to hit the enemy hard at PL KING, disrupt his pursuit, and destroy at least one company each in EAs STING, WHIP, and CHAIN. The 144th GMRR's main effort is expected to be in the right portion of our sector. A Co will probably be hit hardest due to its location on our right and because of the open terrain in its sector. We will fall back to BPs, vic PL JACK, in order to confirm his main effort. As we delay throughout the Bn sector, I plan to keep constant contact with the enemy unless we are forced to pull back to prevent a major penetration. I see few opportunities to shape the battlefield for a counterattack, but we must be ready to launch a limited counterattack if the enemy exposes a flank or appears vulnerable. We will prevent the 39th GMRD from penetrating PL TRUMP until after __1350R ___ 9_. I plan to accomplish this delay in three phases:

(a) Phase I. Cover the BHL with three Cos in BPs 10, 20, and 30, and position at least two platoons forward in each. Accept the battle handover from TF 1-2, and assist as they conduct a rearward passage of lines through our sector on Passage Lanes ELEPHANT, PONY, DOG, AND CAT. Scouts establish observation of enemy forces and follow TF 1-2 through the passage points, then consolidate and screen the left flank. Destroy the lead enemy companies in EAs STING, WHIP, and CHAIN. Displace if an enemy company closes to within 2000 m or when an enemy unit of company size or larger attempts to bypass one of our companies. A Co will probably delay to BP 13 first, overwatched by B Co. B

Co will then delay to BP 23, overwatched by A Co and C Co. C Co will delay to BP 33 overwatched by B Co. Do not cross PL CLUB without permission.

(b) Phase II. Cos continue to defend on successive BPs in the battalion sector. Scouts establish Screen Line ONE along eastern boundary. Bn will be alert for enemy exposed flanks which would present opportunities for counterattack. I anticipate that A Co will be hard pressed on the right flank. As they delay to BP 11, D Co will stage in BP 42, then counterattack into the enemy's flank forward of BP 11. B and C Co will protect D Co's flank, then fall back to and defend from BPs 24 and 34, respectively. A Co will support the counterattack by fire from BP 11, then withdraw to BP 12, consolidate, and reconstitute the Bn reserve. D Co will consolidate on BP 11 after its counterattack. The timing on this limited counterattack is critical. We must anticipate the opportunity and have the forces in motion before it's too late.

(c) Phase III. Continue to attrite the enemy between PL SPADE and PL TRUMP. Be prepared to launch limited counterattacks if opportunities arise. We must force the commitment of the second echelon regiment, 146th GMRR prior to PL TRUMP. Scouts establish Screen Line TWO. Cos occupy BPs vic. PL TRUMP and defend to retain. O/O establish contact with 1-91 Mech scouts at designated Contact Points and conduct BHO and rearward passage of lines through 1-91 Mech on designated Passage Lanes. O/O move to assembly areas (TBD) to become the 1st Bde Reserve.

(2) Fires (Fire Support Overlay):

(a) 1-10 AR has priority of FA Fires within the Bde.

(b) Priority of Fires (FA): Phase I--Scouts, A Co, B Co, C Co, D Co; Phase II, III--A Co, B Co, C Co, D Co, Scouts.

(c) Priority of Fires (Mtrs): Phase I--Scouts, A Co, B Co, C Co, D Co; Phases II, III--A Co, B Co, C Co, D Co, Scouts.

(d) 1-10 AR has two FASCAM minefields available. FASCAM requires Bde Cdr's approval for use.

(3) Obstacles.

(a) Priority of Support: A Co, B Co, C Co, D Co.

(b) Priority of Effort: Countermobility, survivability, mobility.

b. A Co.

(1) Phase I: Defend BP 10. Provide guides for Passage Lane PONY. Engage enemy in EA STING.

(2) O/O delay thru BP 13 to BP 11. Be prepared to defend from BP 13.

(3) Phase II: On order, defend BP 11.

(4) O/O support D Co counterattack by fire.

(5) Phase III: On order, defend BP 12.

(6) On order, conduct rearward passage of lines on Passage Lanes BLUE and GREY.

c. B Co.

(1) Phase I: Defend BP 20. Provide guides for Passage Lane DOG. Engage enemy in EA WHIP.

(2) O/O delay though BP 23 to BP 24. Be prepared to defend from BP 24.

(3) Phase II: On order, defend BP 42.

(4) O/O delay to BP 21.

(5) Phase III: On order, defend BP 41.

(6) On order, conduct rearward passage of lines on Passage Lane YELLOW.

d. C Co.

(1) Phase I: Defend BP 30. Provide guides for Passage Lanes CAT and ELEPHANT. Engage enemy in EA CHAIN.

(2) O/O delay through BP 33 to BP 34. Be prepared to defend from BP 34.

(3) Phase II: On order, defend BP 31.

(4) Phase III: On order, defend BP 32.

(5) On order, conduct rearward passage of lines on Passage Lanes PURPLE and BLACK.

e. D Co.

(1) Phase I-III: Be prepared to reinforce A, B, or C Co sector once enemy's main effort is identified.

(2) Occupy BP 40 initially; be prepared to occupy BP 22.

(3) Be prepared to conduct counterattacks to maintain integrity of the Bn sector or when opportunities arise, with priority of planning for counterattack from BP 42 to relieve pressure on A Co, vic BP 11.

(4) Be prepared to occupy BP 22 and to conduct rearward passage of lines on Passage Lane ORANGE.

f. Scouts.

(1) Phase I: Establish Contact Points 7, 9, 10 and 2 NLT __0800R ___ 9_. Screen forward of PL KING. O/O, conduct rearward passage of lines on routes PONY, DOG, CAT, and ELEPHANT. Consolidate at CP 10, then screen BN left flank from rear of C Co to PL CLUB.

(2) Phase II: Establish Screen Line ONE.

(3) Phase III: Establish Screen Line TWO.

g. Mortars.

(1) Phase I: Occupy initial Firing Point vic ES895810. Be prepared to operate split section to support Bn delay.

(2) Phase II-III: Move under control of Bn FSO. On order, coordinate own rearward passage of lines.

h. 1/A/1-440 ADA. Priority of protection: reserve and TOC.

i. Coordinating Instructions.

(1) PIR:

(a) Concentrations of ten or more tanks.

(b) Use of Chemical munitions.

(c) Use of airmobile opns.

(d) Report penetration of CO size or greater at all PLs.

(e) Report changes in enemy equipment, uniforms, formations, etc. which would indicate commit nt of second echelon units.

(2) MOPP: Level 1 in effect NLT __0950R ___ 9_.

(3) OEG: 70 cGy Report 50 cGy.

(4) Air Defense Warning -- Yellow.

(5) Weapons Control Status -- Tight.

(6) Disengagement criteria: MRC close within 2000 m or when company size unit attempts to bypass your position.

(7) Other Reporting Requirements.

(a) Report BH complete.

(b) Report initial enemy contact.

(c) Report crossing PLs.

(d) Report Passage of Lines complete.

(8) Recognition symbol for rearward passage of lines is orange panel marker front of vehicle during the day -- red flashlight at night.

4. SERVICE SUPPORT. Annex E (Service Support). (Omitted)

5. COMMAND AND SIGNAL.

a. Command.

(1) Succession of Command: SOP.

(2) Cmd Group will be to rear of B Co.

(3) Bn TOC initial location ES866925, subsequent location ES851947.

(4) Alternate Bn CP is Combat Trains CP.

(5) Brigade Main CP located vic ET872023.

(6) Brigade TAC located vic ES877947.

(7) Brigade alternate CP is Bde Tns ET785227.

b. Signal.

(1) SOI index ALPHA in effect.

(2) Radio listening silence in effect __0930R ___ 9_ until first contact is reported or passage of lines completed.

ACKNOWLEDGE:

OFFICIAL:

PATTON
Cdr

HASZARD
S3

Annexes: A--Intelligence
B--Operations Overlay (Omitted)
E--Service Support (Omitted)

Copy ___of ___Copies
1-10 AR, 1st Bde, 23 AD
ES866925
__0530R ___ 9_

ANNEX A (INTELLIGENCE) TO OPORD 200

REFERENCE: Map Series V753, V751 Kentucky - Indiana, Sheets M3753 I, II, III, IV; M3760 II, III Edition 1-AMS, 1:50,000.

Time Zone Used Throughout Order: ROMEO

1. GENERAL. (See Appendix 1, Enemy Situation Overlay)

a. Enemy Situation

(1) Location. The first echelon divisions of the 8th CAA have been stopped by the 52d IN (M). The 1st GTD and the 39th GMRD, second echelon divisions of the 8th CAA, were committed at 0200 hrs this morning to continue the attack northwest along the Elizabethtown to Brandenburg axis. The 1st Bde faces the 39th GMRD, which is currently moving north vic. ES850580 to FS020600.

(2) Strength. The 1st echelon regiments of the 39th GMRD consist of the 140th GMRR, on our right, and the 144th GMRR to our front. These regiments are estimated at 90% strength. The second echelon regiments, the 79th GTR following the 140th GMRR, and the 146th GMRR following the 144th GMRR, are estimated at 95% strength.

b. Enemy Capabilities. The enemy is expected to advance into the 1st Bde sector NET __1000R ___ 9_. They can attack in the brigade sector with 2 MRRs followed by a second echelon, consisting of 1 MRR and 1 TR. The MRRs are equipped with BMP-2s and T-80s. There are unconfirmed reports that the 79th GTR has been upgraded to T-80 Us. Use of chemical agents is anticipated.

c. Most Probable Course of Action. The 144th GMRR will continue to attack NW along the Elizabethown-Brandenburg axis with 2 MRBs (+) in the first echelon followed by 1 MRB (+) in the second. The regimental tank battalion has been split up to provide tanks to each MRB. Each MRB will consist of three (3) MRCs with four (4) tanks each. These MRBs will also probably attack two (2) up and one (1) back. The enemy main effort will most likely be the right portion of our sector, west of Otter Creek. The first echelon MRBs will attack along Avenues of

approach A1 and A2 to seize Bn immediate objectives vic ES860830 and ES930855. Expect the second echelon MRB to be committed at this point along A1 and continue north-northeast to seize the MRR immediate objective vic ES810920 to ES875955. Expect the RAG to support the initial attack from vic ES9174. Significant Bn-size flank AA from the east are: B1--ES9683; B2--ES9294. From the west, two Bn size AA are significant: C1--ES8579 and C3--ES8288, respectively.

2. PRIORITY INFORMATION REQUIREMENTS (PIR)

a. Para 3,i,(1), OPORD 200.

b. Has the 2d echelon MRB been committed to AA A1 (NAI 30, 31, 32, 33, and 34.)?

c. Where has the RAG been positioned (NAI 30)?

d. Is the enemy attempting to attack the Bn flanks (NAI 20, 21, 22, and 23)?

e. Will the enemy conduct airmobile operations (NAI 36 and 45)?

f. Is the enemy headed toward Brandenburg (NAI 33, 34, 35, 42, 43)?

g. Is the enemy in MOPP 3 or 4?

h. Is the enemy using new formations or equipment, such as the T-80U?

3. INTELLIGENCE ACQUISITION TASKS.

a. Subordinate and Attached Units.

(1) A Co. Size, composition, and direction of enemy. (NAI 20, 21, 30, 31, 32, 33, 34, 35, and 36).

(2) B Co. Size, composition, and direction of enemy. (NAI 30, 31, 32, 34, 35, 40, 41, 42, 43, and 45.)

(3) C Co. Size, composition, and direction of enemy. (NAI 22, 23, 40, 41, 42, 44, and 45).

(4) Scouts. Size, composition, and direction of enemy. (Initial--NAI 30, and 40; subsequent--NAI 22 and 23).

(5) GSR. Initial--NAI 30, 31, 40, and 41.

b. Higher and Adjacent.

(1) 1st Bde. (1-92 IN (M)). Size, composition, and direction of enemy. (NAI 20 and 21).

(2) 1st Bde, (210 ACR). Size, composition, and direction of enemy. (NAI 22 and 23).

4. MEASURES FOR HANDLING PERSONNEL DOCUMENTS AND MATERIAL. SOP.

5. DOCUMENTS AND EQUIPMENT REQUIRED. Omitted.

6. COUNTERINTELLIGENCE. Omitted.

7. REPORTS AND DISTRIBUTION. SOP.

8. MISCELLANEOUS INSTRUCTIONS. Omitted.

APPENDICES:

1 -- Enemy Situation Overlay (Omitted)
2 -- NAI/TAI

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__0530R ___ 9_

APPENDIX 2 (NAI/TAI) TO ANNEX A (INTELLIGENCE) TO OPORD 200

REFERENCE: Map Series V753, V751 Kentucky - Indiana, Sheets M3753 I, II, III, IV; M3760 II, III Edition 1-AMS, 1:50,000.

Time Zone Used Throughout Order: ROMEO

1. NAI/TAI Information tasks.

NAI/TAI	Unit	Information
20	1-92 IN (M)	Is enemy attacking flank? Size, composition, direction?
21	1-92 IN (M)	Is enemy attacking flank? Size, composition, direction?
22	210th ACR, Scouts	Is enemy attacking flank? Size, composition, direction?
23	210th ACR Scouts	Is enemy attacking flank? Size, composition, direction?
30	Co A, B Scouts Div Arty GSR	Where is RAG? Has 2d echelon MRB been committed? Size, composition, direction?
31	Co A, B GSR	Has 2d echelon MRB been committed? Size, composition, direction?
32	Co A, B	Has 2d echelon MRB been committed? Size, composition, direction?
33	Co A	Has 2d echelon MRB been committed? Is enemy headed toward Brandenburg? Size, composition, direction?
34	Co A, B	Has 2d echelon MRB been committed? Is enemy headed toward Brandenburg? Size, composition, direction?

35	Co A, B	Is enemy headed toward Brandenburg? Size, composition, direction?
36	Co A	Will enemy conduct airmobile opns? Size, composition, direction?
40	Co B, C Scouts GSR	Size, composition, direction?
41	Co B, C GSR	Size, composition, direction?
42	Co B, C	Is enemy headed toward Brandenburg? Size, composition, direction?
43	Co B	Is enemy headed toward Brandenburg? Size, composition, direction?
44	Co C	Size, composition, direction?
45	Co B, C	Will enemy conduct airmcbile opns? Size, composition, direction?

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1-10 AR, 1ST Bde, 23 AD
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FRAGO 1 TO OPORD 200

Reference: No Change

Task Organization: No Change

1. SITUATION

a. 144th GMRR shifting course from N to NW through the 1-92 IN (M) sector. Enemy right flank is exposed and vulnerable to a counterattack.

b. 1ST BDE counterattacks in sector to destroy the 144th GMRR and force the deployment of 2d echelon regiments of the 39th GMRD.

c. 1-92 IN (M) establishes hasty defenses vic PL CLUB and QUEEN to fix the enemy in sector.

d. 1-91 IN (M) follows 1-10 AR as Bde Reserve. O/O counterattacks through 1-10 AR.

2. MISSION

1-10 AR counterattacks at ____________ (execute time specified by ECR) from current positions along Axis Stingray to seize OBJ ICE (ES855826), attacks by fire into EA SHARK (ES845810) to destroy the 144th GMRR.

3. EXECUTION

a. Concept (see overlay): 1-10 AR counterattacks with three Cos abreast, from left to right: C Co, B Co, and A Co. Counterattack should engage the 144th's 2nd Ech MRB its right flank. Be prepared to withdraw to original sector when 2d echelon regiments are committed.

b. A Co: counterattack along AXIS BETTY to seize OBJ RAIN (ES835835). Orient from TRP 01 to TRP 02.

c. B Co counterattack along AXIS PAM to seize OBJ SNOW (ES854824). Orient from TRP 02 to 03.

d. C Co counterattack along AXIS LIZ to seize OBJ FOG (ES871814). Orient from TRP 03 to 04.

e. D Co support by fire from BP 11. Prepare to reinforce, in priority, B Co, A Co, and C Co.

f. Mortars: follow B Co.

g. Scouts screen Bn left flank from C Co left rear to Bn Bdy. Maintain contact with 210 ACR.

h. Coordinating instructions.

Boundary change: Eastern lateral boundary effective when scouts clear proposed boundary. Western lateral boundary effective immediately.

Phase Line QUEEN and the LD are effective immediately.

4. SERVICE SUPPORT. No Change.

5. COMMAND AND CONTROL

Bn Cdr currently located with B Co vic BP 21.

ACKNOWLEDGE:

OFFICIAL:

PATTON
Cdr

HASZARD
S3

FRAGO 1 Overlay (Omitted)

FRAGO 1 TO OPORD 200 (Oral transcript for Baseline)

FOR TRAINING ONLY

"GUIDONS, THIS IS YANKEE THREE-THREE, ORDERS, OVER."

NOTE: *All subordinate stations respond.*

"FRAGO: ENEMY ATTACK SHIFTING TO NORTH WEST; VULNERABLE TO FLANK ATTACK."

"NOVEMBER COUNTERATTACKS TO DESTROY THE 144TH AND FORCE DEPLOYMENT OF 39TH 2ND ECHELON."

"MIKE DEFENDS TO OUR RIGHT."

"YANKEE COUNTERATTACKS AT __________ (time specified by ECR) ALONG AXIS STINGRAY TO SEIZE OBJ ICE, ES855826; ATTACKS BY FIRE INTO SHARK FROM ES832823 THRU 855811 THRU 835788 THRU 812802; TO DESTROY 144th AND TO FORCE DEPLOYMENT OF SECOND ECHELON REGIMENTS."

"YANKEE ATTACKS WITH THREE COMPANIES ABREAST: FROM LEFT TO RIGHT: CHARLIE, BRAVO ALPHA."

"ALPHA: ATTACK ALONG AXIS BETTY FROM BP 12 THRU ES860890 THRU 860870; TO SEIZE OBJECTIVE RAIN, ES835835. ORIENT SW."

"BRAVO: MAIN EFFORT--ATTACK ALONG AXIS PAM FROM BP 24 TO SEIZE OBJECTIVE SNOW, ES854824. ORIENT SW."

"CHARLIE: ATTACK ALONG AXIS LIZ, FROM BP 34 TO SEIZE OBJECTIVE FOG, ES871814. ORIENT SW."

"DELTA: SUPPORT BY FIRE FROM ONE-ONE; STAND BY TO REINFORCE BRAVO, ALPHA OR CHARLIE IN THAT ORDER."

"SIERRA: SCREEN LEFT FLANK; MAINTAIN FLANK CONTACT."

"SIERRA TWO-ONE: FOLLOW BRAVO."

"BRAVO BLITZ WHEN ALPHA CROSSES SPADE. ALPHA AND CHARLIE KEY ON BRAVO; REMAIN ON LINE."

"WESTERN BOUNDARY CHANGE EFFECTIVE NOW: FROM ES745920 THRU 829840 THRU 799753. EASTERN BOUNDARY EFFECTIVE WHEN SCOUTS CLEAR 210'S NEW SECTOR: BOUNDARY IS FROM ES921982 THRU 925901 THRU 901779."

FOR TRAINING ONLY

"OTHER GRAPHICS EFFECTIVE NOW:

"PL QUEEN: FROM ES834864 THRU 850870 THRU 886876 THRU 924892."

"LINE OF DEPARTURE: NW-SE RUNNING ROAD FROM VICINITY ES850870 THRU 870860 THRU 910847 THRU 953825."

"REPORT REDCON ONE. ACKNOWLEDGE, OVER."

NOTE: *All subordinate units acknowledge. If necessary, paraphrase/describe added graphics.*

FRAGO 1 to OPORD 200 (Text for CVCC digital overlay)

OVERLAY TEXT

FRAGO 1-200
SITUATION
Enemy attack shifting to NW, flank exposed.
Friendly -1st Bde CATKs to destroy 144th, force 39th GMRD to commit 2d Ech.
1-92 def on bn R.
1-91 (Bde Res) O/O CATKs thru 1-10.
MISSION -1-10 CATKs at ____R to seize ICE, fires into SHARK to kill 144th. O/O delays 2d ech MRR.
EXECUTION
D spt/fire from BP11, prep reinf B,A,C.
Coordination -Atk on line, key on B. O/L eff now. 210 Bdy eff when
1-10 clears sector.
END

Close

Copy ___of ___Copies
1-10 AR, 1ST Bde, 23 AD
ES866925
__1310R ___ 9_

FRAGO 2 TO OPORD 200

Reference: No Change

Task Organization: No Change

1. SITUATION

a. Enemy. 2d echelon regiments of the 39 GMRD are moving NW into the Bde sector. ETA: ____ (20 minutes from time of FRAGO publication).

b. 1ST BDE defends along PL ACE to delay the enemy in sector S of PL TRUMP until ____ (approx 2 hrs).

c. 1-92 IN (M) delays in sector on our right flank.

d. 1-91 IN (M) Bde Reserve, reoccupies positions at PL TRUMP, to our rear.

2. MISSION

1-10 AR defends at ____________ (time specified by ECR) along PL ACE (83 E-W grid line). On order, delays enemy S. of PL TRUMP until ____ (approx 2 hrs).

3. EXECUTION

a. Concept (see overlay). 1-10 AR defends from BPs along PL ACE with three Cos abreast; from left to right, C Co, B Co, and A Co. D Co occupies a BP to the rear as Bn reserve. On order, Bn delays in sector.

b. A Co: defend from BP 25; orient toward TRP AQ30. On order, displace to subsequent BPs 11 and 12.

c. B Co: defend from BP 45; orient toward TRP AR30. On order, displace to subsequent BPs 46, 21, and 22.

d. C Co: defend from BP 35; orient toward TRP AT30. On order, displace to subsequent BPs 26, 31, and 32.

e. D Co: occupy BP 46. Prepare to reinforce, in priority, B Co, A Co, and C Co. On order, displace to BP 41.

f. Mortars: locate to rear of B Co.

g. Scouts: screen eastern flank.

h. Companies report when "set" in BPs.

4. SERVICE SUPPORT. No Change.

5. COMMAND AND CONTROL

Bn Cdr will locate to rear of B Co vic BP 45.

ACKNOWLEDGE:

OFFICIAL: PATTON
Cdr

HASZARD
S3

FRAGO 2 Overlay (Omitted)

FRAGO 2 to OPORD 200 (Oral Transcript for Baseline)

"GUIDONS, THIS IS YANKEE THREE-THREE, ORDERS, OVER."

NOTE: All subordinate stations respond.

"FRAGO: SECOND ECHELON MRR IS APPROACHING BN SECTOR FROM SOUTH EAST, ETA: 20 MINUTES."

"NOVEMBER RESUMES DELAY AT PL ACE. BDE DISPOSITION PER ORIGINAL ORDER."

"YANKEE DEFENDS FROM AT _________ (time specified by ECR) ALONG PL ACE (83 E-W gridline), DELAYS ENEMY S OF PL TRUMP FOR ANOTHER TWO HOURS."

"ALPHA: DEFEND FROM BP 25 (ES840840) ORIENT SOUTH. DELAY THRU BPs 11 THEN 12."

"BRAVO: DEFEND FROM BP 45 (ES867840) ORIENT SOUTH. DELAY THRU BPs 46 THEN 21, THEN 22."

"CHARLIE: DEFEND FROM BP 35 (ES896840) ORIENT SOUTH. DELAY THRU BP 36 THREE-SIX (ES902870) THEN BPs 31 AND 32."

"DELTA: OCCUPY BP 46 (ES873875). BE PREPARED TO REINFORCE BRAVO, ALPHA OR CHARLIE IN THAT ORDER. BLITZ TO BP 41 ON ORDER."

"SIERRA ONE ONE: SCREEN LEFT FLANK."

"SIERRA TWO ONE: SUPPORT FROM CENTER OF SECTOR."

"BLITZ WHEN READY, REPORT WHEN SET. ACKNOWLEDGE, OVER."

NOTE: *All subordinate stations acknowledge.*

FRAGO 2 to OPORD 200 (Text for CVCC digital overlay)

OVERLAY TEXT

FRAGO 2-200
SITUATION
Enemy -2d Ech MRR moving
NW into Bn sector, ETA: 20 min.
Friendly -1st Bde resumes delay,
1-92 on our R, 1-91 to rear @PL
TRUMP.
MISSION -1-10 defends at
____R along- ACE, delays En S
of Trump for 2 hrs.
EXECUTION -see O/L.
D: b/prep reinf B,A,C.
Coord: move when ready, report
REDCON 1.
END

Close

Mission and Commander's Intent Statements from Company Orders

Company A

MISSION

A/1-10 AR accepts BHO from and assists in the rearward passage of lines of TF 1-2 NLT __0950R ___ 9_ at PL KING. Then A/1-10 AR defends from BP 10; on order delays through successive BPs forward cf PL TRUMP until __1350R ___ 9_. O/O conducts rearward passage of lines through 1-91 IN (M).

EXECUTION

After rearward passage of TF 1-2, I want to hit the enemy hard in EA STING, disrupt his pursuit, and weaken his 1st echelon battalions. The enemy should approach BP 10 with two companies leading followed by one second echelon company. The enemy's main effort will be directed at A Co due to the open terrain and orientation of the main attack. We will then give ground to vic PL CLUB to determine the enemy's main effort. I want to keep constant contact with the enemy while avoiding decisive engagement and hit him as heavily as possible throughout the remainder of the sector. We need to be ready to hold the ground just south of PL TRUMP and be alert for opportunities for limited counterattacks. We will prevent the enemy from penetrating PL TRUMP prior to __1350R ___ 9_.

Company B

MISSION

B/1-10 AR accepts BHO from and assists in the rearward passage of lines of TF 1-2 NLT __0950R ___ 9_ at PL KING. Then B/1-10 AR defends from BP 20; on order delays through successive BPs until __1350R ___ 9_. O/O conducts rearward passage of lines through 1-91 IN (M).

EXECUTION

After rearward passage of TF 1-2, I want to hit the enemy hard in EA WHIP, disrupt his pursuit, and weaken his 1st echelon battalions. The enemy should approach BP 20 with two companies leading followed by one second echelon company. The enemy's main effort will be directed at A Co, on our right, due to the open terrain and orientation of the main attack. We will then give ground to vic PL CLUB to determine the enemy's main effort. I want to keep constant contact with the enemy while avoiding decisive engagement and hit him as heavily as possible throughout the remainder of the sector. We need to be ready to hold the ground just south of PL TRUMP and be alert for opportunities for

limited counterattacks. We will prevent the enemy from penetrating PL TRUMP prior to __1350R ___ 9_.

Company C

MISSION

C/1-10 AR accepts BHO from and assists in the rearward passage of lines of TF 1-2 NLT __0950R ___ 9_ at PL KING. Then C/1-10 AR defends from BP 30; on order delays through successive BPs until __0950R ___ 9_. O/O conducts rearward passage of lines through 1-91 IN (M).

EXECUTION

After rearward passage of TF 1-2, I want to hit the enemy hard in EA CHAIN, disrupt his pursuit, and weaken his 1st echelon battalions. The enemy should approach BP 30 with two companies leading followed by one second echelon company. The enemy's main effort will be directed at A Co, on the BN right flank, due to the open terrain and orientation of the main attack. We will then give ground to vic PL CLUB to determine the enemy's main effort. I want to keep constant contact with the enemy while avoiding decisive engagement and hit him as heavily as possible throughout the remainder of the sector. We need to be ready to hold the ground just south of PL TRUMP and be alert for opportunities for limited counterattacks. We will prevent the enemy from penetrating PL TRUMP prior to __1350R ___ 9_.

Appendix D

Itemized List of Measures

Command and Control BOS

Receive and Transmit Mission

- Elapsed time from Bn transmission of FRAGO to receipt by Co Cdr
- Duration of Request by Co Cdr/XO to clarify FRAGO/overlay
- Consistency of relayed FRAGO

Receive and Transmit Enemy Information

- Time to transmit INTEL report full net: Bn TOC to lowest manned net
- Consistency of relayed INTEL

Receive and Transmit Friendly Troop Information

- Mean time to transmit SITREP full net: lowest net to Bn TOC
- Mean duration of voice transmissions between Bn TOC & Bn Cdr/S3, except named reports
- Deviation of BLUFOR location reported in SITREP from actual location
- Delay between observed PL/LD/FCL crossing and reported crossing
- Delay between observed BP arrival and reporting SET at BP
- Elapsed time from request for fuel and/or ammo report until received by Bn TOC

Manage Means of Communicating Information

- Average length of voice radio transmissions, by radio network
- Average number of voice radio transmissions, by radio network

Assess Situation

- Percentage of OPFOR tanks correctly identified
- Percentage of OPFOR BMPs correctly identified
- Percentage of own vehicles destroyed
- Destruction of OPFOR vehicles after the order to delay
- Deviation between true and reported distance

Direct and Lead Subordinate Forces

- Did Task Force prevent decisive engagement?
- Did the Bn withdraw intact?
- Number of counterattacking companies engaging OPFOR
- To what extent did the Bn meet the Bde Cdr's intent?

Maneuver BOS

Move on Surface

- Distance between BLUFOR and OPFOR center of mass (CoM), average per Bn
- Time to reach LD
- Exposure index
- Range to OPFOR at displacement
- Time for companies to reach Objectives (Stage 2)

Navigate

- Distance travelled
- Fuel used
- Mean time out of sector/axis
- Mean time misoriented
- Time to complete stage

Process Direct Fire Targets

- Time to acquire targets
- Time between lases to different targets
- Time from lase to first fire
- Maximum lase range
- Number of fratricide hits by manned vehicles
- Number of fratricide kills by manned vehicles

Engage Direct Fire Targets

- Percent of OPFOR killed by end of stage
- Percent of BLUFOR killed by end of stage
- Percent OPFOR vehicles killed by all manned vehicles
- Number of manned vehicles sustaining a killing hit
- Losses/kill ratio
- Mean target hit range
- Mean target kill range
- Hits/round ratio, manned vehicles
- Kills/round ratio, manned vehicles
- Kills/hit ratio, manned vehicles
- Number of rounds fired by manned vehicles, by echelon
- Number of OPFOR vehicles killed south of PL Jack (Stage 1)
- Number of OPFOR vehicles killed south of PL Club (Stage 1)
- Number of OPFOR vehicles killed south of PL Queen (Stage 3)
- Number of OPFOR vehicles killed south of PL Ace (Stage 3)

Control Terrain

- Was the Bn bypassed by the OPFOR?
- Number of OPFOR vehicles penetrating designated line (Stage 1)
- Number of OPFOR vehicles penetrating designated line (Stage 2)
- Number of OPFOR vehicles that crossed PL Queen (Stage 3)

Fire Support BOS

Process Ground Targets

- Mean accuracy of CFF locations
- Percent of CFFs with correct type
- Mean number of unique CFFs sent

Intelligence BOS

Collect Threat Information

- Accuracy of CONTACT report locations
- Accuracy of SPOT report locations (observed and destroyed)
- Accuracy of SHELL report locations
- Percent CONTACT reports with correct type
- Correctness of SPOT report number and type (observed and destroyed)